

WEEKLY NEWS IDEAS INNOVATION

19 JUN 2007

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NewScientist

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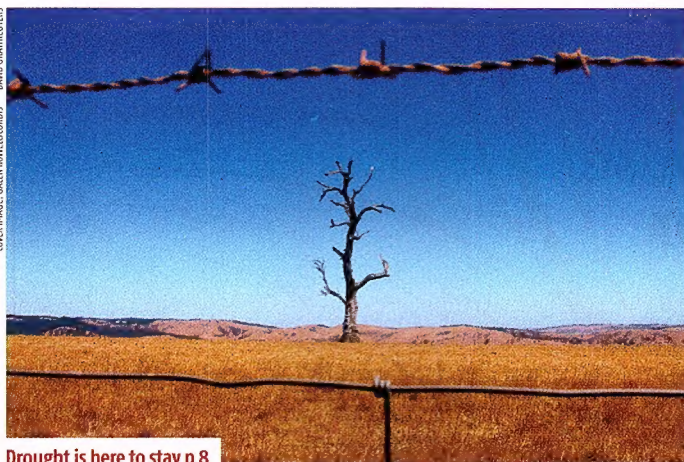
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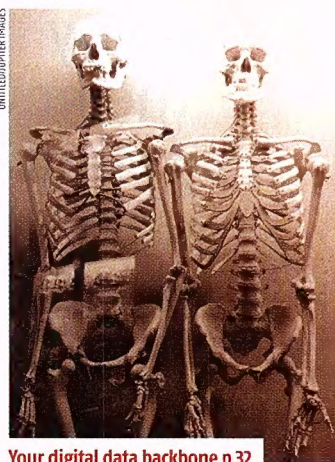


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"I was fired and blackballed. The speaker said he would look darkly on me being employed by anyone within his realm of influence"

Lawyer Jeff Ruch learned the hard way that whistle-blowers need protection, page 52



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Not such a lucky country

For a taste of what climate change can mean, look no further than Australia

OVER the past 50 years southern Australia has lost about 20 per cent of its rainfall, and one cause is almost certainly global warming. Similar losses have been experienced in eastern Australia, and although the science is less certain it is probable that global warming is behind these losses too. But by far the most dangerous trend is the decline in the flow of Australian rivers: it has fallen by around 70 per cent in recent decades, so dams no longer fill even when it does rain. Growing evidence suggests that hotter soils, caused directly by global warming, have increased evaporation and transpiration and that the change is permanent. I believe the first thing Australians need to do is to stop worrying about "the drought" – which is transient – and start talking about the new climate.

While the populated east and south of Australia have parched, rainfall has increased in the north-west. This has prompted some politicians to call for development of the north, including massive schemes for dams and pipelines (see page 8). Some have even called for a large-scale shift of population to follow the rain. Yet computer models indicate that the increased rainfall is most likely caused by the Asian haze, which has pushed the monsoon south. This means that as Asia cleans up its air, Australia is likely to lose its northern rainfall. Australians need to leave behind their dreams of opening a new frontier and focus on making the best of the water remaining to them where they live today.

To achieve this, much has to be done. Industry, power plants, farmers and households pay too little for their water, so they waste it. Water thrift is an absolute prerequisite for life in the new climate. The country also needs to shift to a new energy economy. Australia's coal-fired power plants consume around 2 tonnes of water – for cooling and steam generation – for every megawatt-hour they produce. They also emit much of the CO₂ that is the ultimate cause of the drying. Dwindling water supplies are raising the price of electricity, and to avoid an economic and environmental disaster the old coal clunkers need to be closed as quickly as possible and replaced with cleaner, less thirsty means of power generation. These could include geothermal, solar thermal, solar, wind or wave energy, and possibly clean coal.

Australia needs to design and build an

irrigation system fit for the 21st century. It is tempting is to try to fix the existing system, but that is hopeless. The country needs to move to highly efficient irrigation and to think laterally about water use. As the climate becomes more variable it may make sense, for example, to plant rice and cotton during the odd wet year, rather than persist with permanent plantings of grape, citrus and so

"Some may say that Australia deserves its fate, but to save itself from worse climate impacts it needs to change its ways, and fast"

on, which need water year-round.

The cities need drought-proofing by, for example, installing water tanks in all dwellings that can accept them. Because in affected areas the decline in river flow is three times that in rainfall,

water tanks that use roofs as catchments are now far more effective than dams for supplying drinking water in cities such as Sydney and Brisbane. Recycling can help too. This needs new investment and in some instances will require state government water monopolies to be broken up. It will cost more, but the benefits in terms of water security and recapture of nutrients in solid wastes are immense.

Desalination plants can provide insurance against drought. In Adelaide, Sydney and Brisbane, water supplies are so low they need desalinated water urgently, possibly in as little as 18 months. Of course, these plants should be supplied by zero-carbon power sources.

Last, but by no means least, Australia must ratify the Kyoto protocol and agitate globally for a swift and decisive reduction in greenhouse gas emissions. Our best theories show that Australia is suffering early and disproportionately from climate change. As one of the two renegade developed nations not to have ratified the treaty (the other is the US), and as the world's worst per capita emitter of CO₂, some may say that Australia deserves its fate. If it is to save itself from even more severe climate impacts the country needs to change its ways, and fast. **Tim Flannery** ●

Tim Flannery is professor of earth and life sciences at Macquarie University, chair of the Copenhagen Climate Council, and the 2007 Australian of the Year

Upfront

STREET SEX WORK TAKES ITS TOLL

Prostitutes working on the streets suffer far greater damage to their health than those who work in massage parlours, according to a survey of sex workers in Bristol, UK. The findings also reveal serious gaps in health provision for all sex workers, and provide fresh ammunition to those who argue for the legalisation of brothels.

"The major factor driving bad health among street prostitutes is drug use," says Nikki Jeal of Cardiff University, UK, who conducted the survey with Chris Salisbury of the University of Bristol. Only four of the 71 parlour interviewees used heroin, compared with 60 of the 71 street workers. The picture was similar for injected drugs generally, and also for crack cocaine.

As a result, street workers had a higher rate of health problems such as abscesses, deep vein thrombosis, chest

infections and hepatitis B and C. They were also more likely to suffer from anxiety and depression. "For the street workers, rehab is key to solving their health problems," says Jeal.

Parlour workers suffered only half the amount of illness reported by street workers. They were also more likely to get screened regularly for sexually transmitted diseases and to use other contraceptives in addition to condoms. However, they still had unmet health needs, such as hepatitis B vaccinations.

"Although they are all labelled as sex workers, their health needs are very different," says Jeal. She suggests that the authorities should provide extra services such as dedicated health workers. Sara Walker of the English Collective of Prostitutes says this would work only if the services were independent from the criminal justice system.



Get thee to a massage parlour

Inflammable

THE logging industry has had its fingers burned. Turning dead trees into logs after forest fires seems to exacerbate forest damage in any subsequent fires.

"For a long time there was a perception that by salvage-logging fire-killed trees, you would be removing a lot of potential fuel for future fires," says Jonathan Thompson of Oregon State University in Corvallis. The logging industry is keen on salvage logging because commercially valuable trees such as conifers can be planted (*New Scientist*, 5 August 2006, p 4).

Thompson and colleagues

than 800 hectares were logged to salvage any wood that could be sold, and the land was replanted with conifers. The team discovered that areas logged for salvage burned between 16 and 61 per cent more severely during a second fire than areas left to regrow naturally (*Proceedings of the National Academy of Sciences*, vol 104, p 10743).

Thompson now says this type of forest management should not be used in an attempt to limit the risk of future fires, although he says it may still have economic value. The satellite data wasn't detailed enough to allow the team to determine whether it was the logging or the replanting that made the second fire worse in certain areas. Salvage-logging operations can leave a lot of the higher branches on the ground, where they can fuel future fires, says Thompson, but it is difficult to say how much of an effect this would have had 15 years later.

He says it is more likely that the conifers which replaced the original forest provided a homogenous fuel for the 2002 fire, causing replanted areas to burn more fiercely.

"Areas logged for salvage burned 16 to 60 per cent more severely in a second fire"

studied before and after satellite images of two large fires in south-west Oregon. The 2002 Biscuit fire engulfed more than 200,000 hectares, over 18,000 of which had already been burned in the 1987 Silver fire. In the three years after the Silver fire, more

Flaws corrected

THE journal *Nature* has published a correction to a high-profile stem cell paper following questions raised by *New Scientist*.

In 2002, Catherine Verfaillie and her team described stem cells from mouse bone marrow that appeared to be as versatile as embryonic stem cells (*Nature*, vol 418, p 41). In 2006 *New Scientist* queried plots describing characteristics of the cells' surfaces, and this year, after an inquiry by the University of Minnesota, Verfaillie wrote to

Nature to caution that these results were flawed (*New Scientist*, 17 February, p 12). *Nature* has now issued a correction, though it says the paper's original conclusions still stand.

Further questions surround a 2001 paper in *Blood* (vol 98, p 2615), describing similar cells from human volunteers. This year *New Scientist* revealed (24 March, p 12) that this contains images used in a US patent to describe other results. On 9 May *Blood* posted a warning about the apparent duplications, which it says are under review.

SHUTTLE BLANKET NO COMFORT

It's a problem that won't go away. The launch of NASA's shuttle *Atlantis* on Friday was marred by damage to its heat shield, recalling the *Columbia* shuttle disaster in 2003.

During launch, the corner of a thermal blanket used to protect one of the shuttle's engines near its tail peeled back (see Photo). The 10-centimetre tear is a worry because *Columbia* disintegrated on re-entry after its heat shield was damaged by insulating foam

that broke off during take-off.

After the shuttle docked with the International Space Station on Sunday, engineers decided that the blanket must be repaired in orbit. This contrasts with a similar event in 2005, when a damaged thermal blanket on the shuttle *Discovery* was left unfixed.

The astronauts aren't at risk, says NASA, but the honeycomb graphite material under the tear could suffer more damage, requiring ground repairs.

Finally a warning

IT HAS taken a while, but on 6 June the US Food and Drug Administration announced the diabetes drug Avandia will soon come with a prominent "black box" warning about the risk of congestive heart failure. Experts reviewing the drug for the FDA first called for one over a year ago.

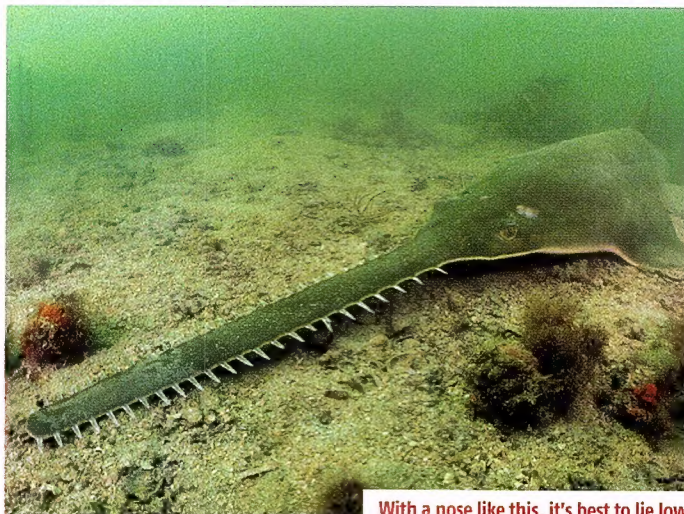
"Some say the delay is another example of industry versus science, with science the loser"

Some say the delay is another example of industry versus science, with science the loser.

An oral drug that lowers blood sugar, GlaxoSmithKline's Avandia has been used by patients with type 2 diabetes since 1999. Concerns over possible heart-related side effects were raised by diabetes specialists in 1999, and again last year by FDA reviewer Rosemary Johann-Liang, who says the FDA ignored her proposal for a stronger warning. The FDA is investigating her claims.

With drug makers pushing for speedy approvals, science is often sacrificed and reviewers' opinions stifled, says Francesca Grifo, director of the Scientific Integrity Program at the Union of Concerned Scientists in Washington DC.

Legislation to boost the evaluation of drugs' safety after they go on sale is being debated in the US House of Representatives this week.



With a nose like this, it's best to lie low

Fishy deal

IT HAS been a mixed week for fish. The 169 signatories of the Convention on International Trade in Endangered Species (CITES) met in the Dutch city of the Hague and banned nearly all trade in sawfish, whose toothy snout is all too popular with collectors (see Photo).

CITES also said European eel exports must be controlled. But the controls will have to wait 18 months for a management

plan, a sought-after pet in Japan, and defeated a US bid to remove restrictions on bobcat pelts. It also knocked back Japanese efforts to engineer support for dolphin and whale hunts. But as *New Scientist* went to press it was not yet clear if CITES would allow a one-off sale of confiscated African ivory, which might help fund elephant conservation, but which some fear will encourage poaching.

Trading jibe

CARBON trading is becoming "emission impossible", according to the pun-tastic environment group WWF. It says European companies are planning to meet their commitments to cut greenhouse gas emissions by investing in dubious projects in the developing world, rather than schemes that will genuinely help reduce carbon emissions.

Companies are allowed to meet Kyoto targets by trading in emissions permits, effectively buying permission to pollute. The European Emissions Trading Scheme allows companies to purchase credits by investing in projects outside the EU, but WWF questions whether schemes such as Indian hydroelectric power plants, or others apparently aimed at reducing China's emissions of industrial greenhouse gases, will really help prevent climate change.

"CITES banned trade in sawfish, whose toothy snout is all too popular with collectors"

plan to take effect – European Union ministers approved it separately this week. Eel numbers have plummeted, partly because of overfishing of baby eels, which are shipped to Chinese eel farms for fattening then sold to Japan. The new CITES law aims to keep 60 per cent of the babies caught to restock European rivers, but that number will fall if Asian eel prices rise, which is likely as European exports fall.

Still, eels got a better deal than sharks: CITES initially refused to restrict trade in the porbeagle and spiny dogfish, although Europe is pushing for another vote.

Mammals fared slightly better. CITES banned trade in Asia's slow

Plants know their kin

Some plants recognise and cooperate with close relatives, and compete with "strangers", say Susan Dudley and Amanda File of McMaster University in Ontario, Canada. They report that the Great Lakes sea rocket (*Cakile edentula*) "competed" by putting out extra roots when grown in trays alongside "stranger" plants (*Biology Letters*, DOI: 10.1098/rsbl.2007.0232).

Ghost of Titan's ocean

An enigmatic radio signal detected by the European Space Agency's Huygens probe as it descended to Saturn's moon Titan could turn out to come from an ice-covered ocean. Fernando Simoes of the Centre for the Study of Terrestrial and Planetary Environments in Saint Maur, France, says an echo in the radio signal could have reflected from the boundary between the ice and water.

Pig plague fear

African swine fever, a devastating pig virus rare outside Africa, has stunned animal health experts by invading the Caucasus. A south-east African strain has already spread across Georgia and may have reached neighbouring countries. An as yet unidentified disease ravaging Chinese pigs may also be ASF.

Worms in space

A colony of nematodes will return home on 19 June from a six-month stay on the International Space Station, where they have bred for 25 generations. Researchers from Simon Fraser University in British Columbia, Canada, hope that studying the mutations the worms have accumulated will help us understand and mitigate the effects of lengthy exposure to radiation in space.

Cancer patients left in pain

More than half of European cancer patients questioned suffer moderate to severe pain, yet 1 in 5 of those are not being treated for it. The European Pain in Cancer survey, covering 4824 patients, is the largest ever study into the prevalence, impact and treatment of cancer-related pain.




Small tear, big worry

This week Drought

Australia is in the grip of an epic drought. It now faces some tough decisions about how its people are going to live on a land with ever-diminishing water supplies. **Rachel Nowak** reports

THE CONTINENT THAT RAN DRY

IAN WARD/GETTY IMAGES



"Water will still come out of the tap. But at what cost?"

IN THE beginning the Australian drought was fun. A talking point over the barbecue, an excuse to shower with a lover or spend more cloud-free days with friends at the beach. Tales of thirst-crazed camels rampaging through country towns merely added to the excitement.

Sometime last year, the mood changed – perhaps with the first inkling that water restrictions had all but destroyed urban gardens and that agricultural production across the country had fallen by a fifth. Last month, when water storage fell so low that energy supplies were threatened, the sense of panic became palpable. Australia is facing a national crisis, one that promises to transform the country, inexorably changing where people live, what they eat, what they do in their spare time, and – most threatening of all – their future economic well-being.

Whether Australia can adapt remains to be seen, and water experts around the world will be following closely as regions as far afield as the south-east and south-west US, and

south-west China grapple with their own droughts. "Water will still come out of the tap, but at what cost?" asks Chris Mitchell of CSIRO Marine and Atmospheric Research (CMAR) in Melbourne. "Will we adapt and ameliorate the problem or adapt and exacerbate it?"

Across the continent, average rainfall has actually increased marginally over the past century. But there has been a shift in where rain falls. Since the 1970s the unpopulated regions of the north have got wetter, but the southern and eastern regions, where most people live, are drier.

To make matters worse, Australia's average temperatures have been increasing at an accelerating rate in the past 20 years. Seven of the past 10 years have been hotter than average, and four states have just clocked up their warmest autumn on record. Higher temperatures increase evaporation, making a bad drought even worse.

Today large swathes of six of Australia's seven states and territories, and all of Australia's major cities, are officially "in drought" and have been ►

For many regions, this year has been the driest on record

This week Drought

for years. That's in spite of the rain that has fallen over the past few weeks, and the once-in-30-years storms and floods that hit Hunter valley, north of Sydney, last weekend. Because the land is bone dry, it has simply sucked up the rain. That has helped some farmers but water run-off is still well below average and the level of reservoirs remains perilously low (see Diagram, p 11).

Melbourne's water storage stands at 28 per cent of its capacity. Sydney's is at 37 per cent. Perth, where rainfall has fallen 15 per cent in the past half-century, and inflows into the dams by more than 40 per cent, now accepts drought as the norm, and has dropped its expected annual catchment from 340 to 180 gigalitres. Last year, just 120 gigalitres flowed into its dams.

"People have been taken by surprise at the speed this has happened," says John Langford, director of UniWater, a research initiative shared by Monash and Melbourne Universities. What makes the Big Dry more shocking is that just 10 years ago, Australia was considered drought-proof. Precisely because the country is so susceptible to huge variations in rainfall, the nation-builders of the 1950s and 1960s equipped city and country with massive multi-year reservoirs, providing the highest water storage

capacity per capita in the world, and plumbed in hundreds of kilometres of irrigation channels. What they hadn't bargained for was the thirst of the country's growing population, or just how brutal a drought could be.

Australia sits at the centre of three oceans, the Indian, the Pacific and the Southern. Its reputation as the driest inhabited continent on Earth, and the one with the most variable rainfall (in the 1970s, large parts of Australia were beset with floods), depends on a complex interplay between these oceans and the atmosphere.

The best understood system is the El Niño-Southern Oscillation. During El Niño events, which usually peak in the Australian summer, warm water develops in the eastern and south-eastern tropical Pacific, triggering differences in air pressure that drive rain that should fall onto eastern Australia out over the ocean. Australia has had two such El Niños in quick succession, one in 2002 and 2003, and one in 2006 and 2007, with no intervening wet periods.

Since 1997, the Indian Ocean Dipole – a cooling of the tropical eastern Indian Ocean, and a warming of the west – has also been more active, reducing spring rains in south-east Australia. Finally, winter rains have dropped off due to



Pejar dam, which serves the people of Goulburn, ran dry in 2006

changes in the Southern Annular Mode, a climate pattern that prevents rain-bearing low-pressure systems reaching southern Australia.

A large portion of the drought-inducing changes is undoubtedly due to natural variation. But there is the possibility that climate change, especially rising temperatures, has turned a severe drought into a historic one. In Australia's worst-hit region, Perth and the south-west, increases in greenhouse gases account for about half of the reduction in rainfall, according to an analysis of 70 experiments using 21 climate models by Wenju Cai of CMAR and CSIRO colleague Tim Cowan (*Geophysical Research Letters*, vol 33, p L247098).

For many water experts the spectre of climate change makes arguments over the cause of the current drought almost irrelevant: the most recent assessment by the Intergovernmental Panel on Climate Change was confident that climate change would make the southern regions of Australia where most people live warmer and drier, and more susceptible to extreme variations in weather. In other words, Australia may survive this drought, but there will be more to come.

"For our major cities, supply will fail to meet demand by 40 per cent by

MURRAY RIVER SYSTEM DRIES UP

Talk about drought in Australia, and conversation quickly turns to the Murray-Darling Basin (MDB). This monster river system symbolises the difficulties of divvying up an ephemeral resource like water.

The rivers of the MDB cross four states and one territory, each of which hands over some of its water management responsibilities to a mishmash of often overlapping local authorities. Add in a shrinking water supply, a growing population, and the competing needs of irrigation, industry, the environment and water for drinking, and it is easy to see why no one's happy.

Long before the current drought, water extraction had pushed the MDB to breaking point, slowing its rivers, increasing their salinity and nutrient concentrations, and altering their

temperatures. With the drought, farmers, who rely on the MDB to produce 40 per cent of the nation's food and fibre, are suffering too – their pain became international news in April when Prime Minister John Howard announced that they won't see a drop of irrigation water until significant rains fall.

Nor are city dwellers happy. The Murray was once the most reliable source of water for Adelaide, a city of 1.1 million. Now the river threatens to fall below the level of the pumps.

The latest attempt to rectify the situation is Howard's "National Plan for Water Security", revolving around revamping irrigation in the MDB. Its aims, to give farmers less water and to better police and measure water in the basin, have won support from water experts. Others fear that plans

to plug leaks in the hundreds of kilometres of decrepit irrigation channels will backfire on the environment: up to 60 per cent of the leaking water returns to the rivers, bolstering what little flow there is.

What everyone agrees is that agriculture in the MDB will change. At the very least, the amount of irrigated pasture for dairy will decrease. Some farmers may even move to the wet, northern reaches of the continent – an option being examined as part of Howard's new plan.

"The current pattern of agriculture and settlement was based on a certain set of climatic conditions. If they don't continue, everything gets thrown up in the air," says Daniel Connell of The Australian National University in Canberra, author of *Water Politics in the Murray-Darling Basin*.

KEEPING COOL OVER ENERGY

"You can't put a tight little boundary around the water issue," says Barney Foran, a policy analyst at The Australian National University in Canberra. As well as being a trade, environment and population issue, it is an energy issue, he says.

In the last few months dwindling water supplies have forced Victoria's major power stations to buy in water for cooling to supplement local sources. Queensland has turned off two of its generators, reducing its total capacity by 700 megawatts. Meanwhile, dams holding water to power hydroelectric turbines in the snowy mountains of New South Wales are at their lowest levels, containing just 8 per cent of the

water once available for power generation. That has forced the government to temporarily waive environmental restrictions to allow fuller use of gas-fired power plants.

Water scarcity has also helped double the wholesale price of electricity from A\$30 (\$25) to A\$60 per megawatt-hour. According to a recent report from the National Electricity Market Management Company, which manages most of Australia's electricity supply, the lack of water could cut the total energy available by up to 10 per cent by late 2008. Such a shortfall would drive up electricity prices, and lead to rationing and rolling blackouts during the summer, when air conditioners send electricity consumption soaring.

2025. We will need another 800 to 1000 gegalitres per year," says Tom Hatton, director of CSIRO's Water for a Healthy Country Flagship. In comparison, Perth, Australia's fourth largest city, uses 300 gegalitres a year. "That's based on projected population growth, and in hindsight, on rather optimistic estimates of the improved efficiency with which we can use water, and rather conservative estimates for declines in rainfall."

Can technology keep the water flowing? All but the greenest policy-makers now see desalination plants as essential, at the very least as back-ups to see Australia through this and future droughts. But you need huge amounts of energy to pump seawater through membrane filters, and the waste brine created by desalination is bad news for the environment.

Perth completed its first desalination plant last year, with a new wind farm being built to supply the electricity and offset the 24 megawatts required to run the plant. Desalination now supplies 17 per cent of the city's drinking water and a second plant has been commissioned. Sydney is building one, and Melbourne is expected to follow suit. Industrial plants which depend on a secure water supply, such as BHP Billiton's copper

and uranium mine in South Australia, are considering building their own large desalination plants.

Recycling waste water could be a more sustainable option because it uses roughly a third of the energy required to desalinate seawater. But last year Toowoomba, Queensland's largest inland city, overwhelmingly voted to reject adding recycled effluent to the water supply, making politicians elsewhere nervous about introducing similar measures. Nonetheless, Queensland's government hopes to start recycling sewage before Brisbane's main water supply runs dry early in 2009. Most experts agree that recycled water will be supplementing Australian drinking supplies within the decade.

Even the politically unpopular and costly option of piping water from one catchment area to another – robbing Peter to pay Paul – will become more common. "Desalination, recycling and piping all cost more energy per unit volume of water than traditional reservoirs," says Hatton. That worries climate experts, because more energy tends to mean more greenhouse gases, which in turn will exacerbate climate change and future droughts.

Hatton believes we can still save the day by reducing demand for water, for example by increasing its price, and by making the same water stretch further. The Water for a Healthy Country Flagship is developing new techniques

to bring down the economic and environmental costs of desalination and recycling, and to improve how water use is measured, which in turn will make water use more efficient. It is also working on new storage techniques, including "managed aquifer recharge", in which partly recycled water is pumped into underground aquifers. Not only does that reduce evaporation, which can be significant from a dam surface, but water quality also improves with time as pathogens die off.

Not everyone is convinced this will be enough. "You can fiddle around with technology, but there is a limit to the amount of water available. Population needs to be part of the discussion," says Graeme Pearman, director of the Monash Sustainability Institute at Monash University in Melbourne. He and others say people are failing to address the impact of Australia's burgeoning population, expected to grow from 21 million to between 25 and 33 million by 2051, for fear of appearing racist or anti-development.

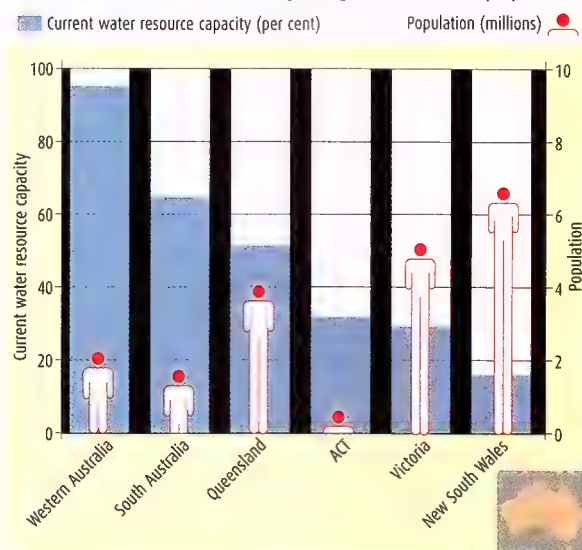
That attitude may be starting to change. In March, delegates at a high-profile conference in Canberra on population and water use discussed the need both for a national population policy that took into account the scarcity of resources such as water, and for more strategic regional planning that ensures new settlements follow the water rather than vice versa.

Barney Foran, a policy analyst at The Australian National University in Canberra, says Australians must also address their per capita water use. When you factor in the water used to make products such as food, drink, clothing and newspapers, the average Australian consumes roughly six to eight times more water than what their domestic water meter records, with more affluent Australians consuming twice as much as less affluent ones.

Meanwhile, illogical as it seems, the biggest obstacle to dealing with an ever drier Australia could be rain itself. "We have a window of opportunity," says Quenton Grafton of The Australian National University. "My concern is that if the drought breaks then people's attention will move on to something else. Five years down the track when we have another drought – which will happen – we won't be ready." ● (See editorial comment, page 5)

WATER SHORTAGES FOR AUSTRALIA

In many parts of Australia, water shortages are greatest where most people live





Not as dumb as they look

Neanderthals bid for human status

ROWAN HOOPER

NEANDERTHALS as innovators? That the concept seems amusing goes to show how our sister species has become the butt of our jokes. Yet in the Middle Palaeolithic, some 300,000 years ago, innovation is what the Neanderthals were up to.

This period is usually regarded as undramatic in cultural and evolutionary terms, with little in the way of technological or cognitive development. Palaeoanthropologists get more excited about the changes in tools found later, as the Middle Palaeolithic gave way to the Upper, and as modern humans replaced Neanderthals, some 40,000 years ago.

Terry Hopkinson of the University of Leicester, UK, has now challenged this view, showing that Neanderthals were

far from behaviourally static. They incorporated different forms of tool construction into a single technique, and learned to cope with the ecological challenges posed by habitats in eastern Europe.

"There has been a consensus that the modern human mind turned on like a light switch about 50,000 years ago, only in Africa," says Hopkinson. But the putatively modern traits accompanying the change, such as abstract art, the use of grindstones and elongated stone blades, and big game hunting began to accumulate in Africa from 300,000 years ago, he says. "It was the same in Europe with Neanderthals, there was a

"As with *Homo sapiens* in Africa, Neanderthals gradually accumulated technology and developed human traits"

gradual accumulation of technology." If *Homo sapiens* developed human traits gradually, then why not Neanderthals?

Archaeological finds from across Europe show that the Neanderthals fused two forms of toolmaking, the *façonnage* and the *débitage* techniques. In the former a stone core is shaped by chipping off flakes of flint, the latter involves producing sharp-edged flakes from a core. In the Lower Palaeolithic, more than 300,000 years ago, the two techniques were practised separately, but Hopkinson argues that during the Middle Palaeolithic they were fused into a single method, the Levallois reduction technique (*Antiquity*, vol 81, p 294).

At the same time as this was occurring, excavations show that Neanderthals spread into central and eastern Europe, regions where they and their forebears, *Homo heidelbergensis*, had hitherto been unable to settle. In western Europe, the influence of the Atlantic ameliorates the extreme seasonality of the continent, but away from this, the environment was too harsh for them to cope. "The eastern expansion shows that the Neanderthals became capable of managing their lives and their landscapes in strongly seasonal environments," says Hopkinson.

This period is commonly thought to be characterised by long periods of little change in technological and perhaps also cognitive development, says Katerina Harvati of the department of human evolution at the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany. "This analysis highlights important aspects of Neanderthal cultural and cognitive evolution which are not always emphasised," she says.

Neanderthals have typically been thought of as incapable of innovation, as it was assumed to be something unique to *Homo sapiens*, says Hopkinson. "With this evidence of innovation it becomes difficult to exclude Neanderthals from the concept of humanity." ●

"Science is a gift of God to all of us and science has taken us to a place that is biblical in its power to cure."

Nancy Pelosi, Speaker of the US House of Representatives, arguing for a bill to ease restrictions on federal funding of embryonic stem cell research (*The New York Times*, 8 June)

"Recent scientific developments have reinforced my conviction that stem cell science can progress in ethical ways."

President George Bush, who has pledged to veto the House of Representatives' bill on embryonic stem cell research on the basis that amniotic or adult stem cells could be used instead (*The New York Times*, 8 June)

"It was a very evangelical meeting. Others who were there said it was like a Billy Graham sermon."

Tim Worner, who runs a UK multiple sclerosis support group, on a presentation by charity Proventus lobbying for greater access to an unlicensed MS treatment called Aimspro, derived from goat serum containing killed HIV virus (*The Guardian*, London, 11 June)

"An act of sabotage, against tourism, against research."

Paulin Ngobobo of the Congolese Institute for the Conservation of Nature on the apparent killing of a female mountain gorilla in the Virunga nature reserve by a local rebel group, which conservationists fear is targeting the gorillas (AFP, 10 June)

"It's great for people who otherwise might have sat around all night waiting to see a moonbow."

Don Olson of Texas State University, who has created a computer model to predict the precise date and time of moonbows, which form when a full moon's rays hit rain or the mist of a waterfall (*San Francisco Chronicle*, 3 June)

Angry reception greets patent for synthetic life

THE enfant terrible of genomics is at it again. First Craig Venter's company Celera raced publicly funded researchers to sequence the human genome. Now his research institute is trying to patent a "minimal genome", which could be used to make synthetic life forms.

The ETC Group, which is concerned about the societal and environmental implications of new technologies, fears that Venter will create a "Microbesoft" monopoly in the burgeoning area of synthetic biology – a supercharged form of biotechnology that aims to create living "machines" (*New Scientist*, 20 May 2006, p 43). The patent application has also annoyed

biologists who are trying to foster an open-source movement. But the claim that Venter is about to become the Bill Gates of synthetic biology is wide of the mark, say his scientific rivals.

"It's the philosophical stake in the ground that will really tick people off," says Tom Knight, a synthetic biologist at Massachusetts Institute of Technology. "The good news is that what they're claiming is a lot more limited than people realise."

The US patent application, which comes from Hamilton Smith's team at the J. Craig Venter Institute in Rockville, Maryland, claims ownership of a set of less than 400 genes required to sustain a

free-living microbe. The patent states that a synthetic genome bearing the genes could be inserted into a bacterium stripped of its own DNA. The idea is that this bacterium will become a "chassis" for a synthetic organism carrying genetic circuits with novel functions. The patent also claims a specific application: producing ethanol or hydrogen for fuel.

"We believe these monopoly claims signal the start of a high-stakes commercial race to synthesise and privatise synthetic life forms," says Jim Thomas, an ETC researcher based in Montreal, Canada.

But George Church, a synthetic biologist at Harvard University, predicts that many in the field will

prefer to build their living machines using a standard bacterium such as *Escherichia coli*. And even if they do want to build a stripped-down synthetic organism, it should be relatively easy to sidestep the patent. Venter's own group published a paper on a slightly larger minimal genome in 1999, placing that information in the public domain. This means you could get round the patent simply by packing a synthetic genome with a few dozen more genes, says Knight.

The patent also gives no details on how to create a synthetic organism. "I would be perfectly happy filing a patent on mechanisms of creating an organism of this kind," says Knight. "That is not what this is."

Venter could not be reached for comment before *New Scientist* went to press, but rumours are circulating that his institute will soon unveil the first synthetic bacterium. Peter Aldhous ●

"We believe these monopoly claims signal the start of a high-stakes commercial race to privatise synthetic life forms"

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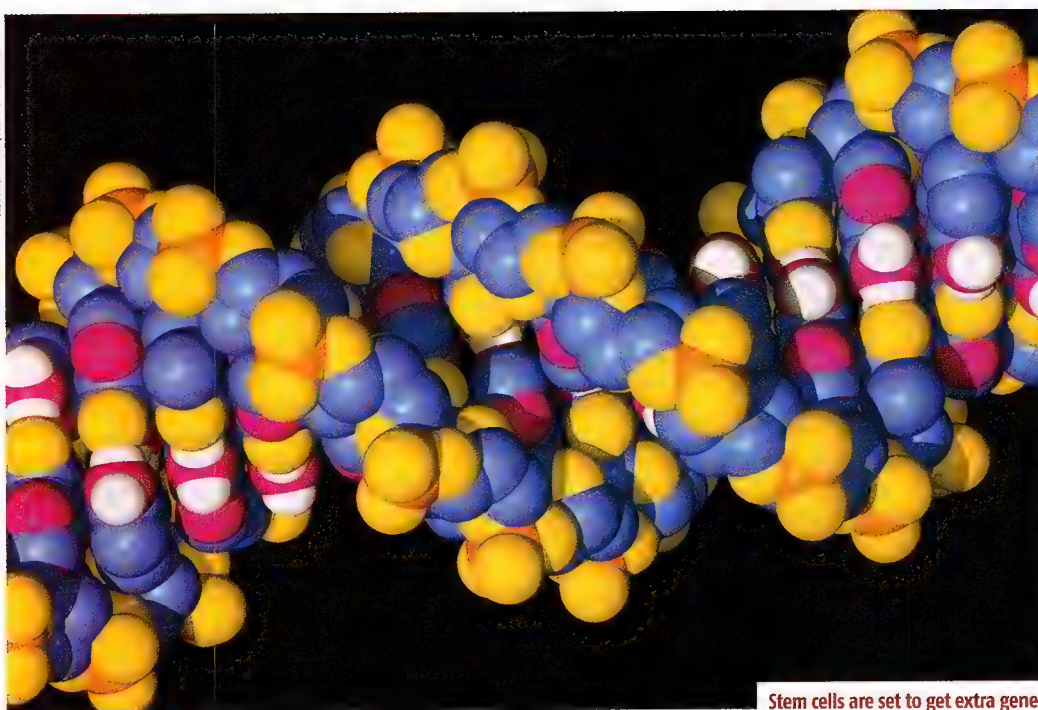


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Stem cells are set to get extra genes

A dream ticket for tackling disease

PETER ALDHOUS, SEATTLE

GENE therapy meets stem cells. That is the wave of the future, if the recent annual meeting of the American Society of Gene Therapy in Seattle is any guide. There was a palpable buzz around efforts to correct diseases by targeting therapeutic genes to stem cells already resident in the body.

Clinical trials are on the horizon for treatments for diabetes and a group of fatal neurodegenerative conditions called lysosomal storage diseases. Meanwhile, gene therapists are also using their skills to make "improved" stem cells for regenerative therapies (see "Stem cell enhancement"). "If you look at what is happening today and what is in the pipeline, I think genetic modification of stem cells is going to be a major theme," says Luigi Naldini of the San Raffaele Telethon Institute of

Gene Therapy in Milan, Italy.

Stem cells have obvious appeal as targets for gene therapy, in which genes are inserted into an individual's cells in order to treat a disease. Once modified to carry a therapeutic gene, stem cells should continue to divide as normal, replenishing themselves and producing specialised daughter cells that will carry the same gene. By contrast, most other cells have a limited lifespan and capacity for division – one reason why gene therapists have so far struggled to achieve effective and lasting treatments.

Indeed, the most conspicuous success of gene therapy to date – the treatment of children with a severe inherited immune deficiency – was achieved by correcting genetic defects in blood-forming stem cells in their bone marrow. Now gene therapists are focusing on other types of

stem cells and different diseases.

Among the most promising examples in Seattle was a therapy for type 1 diabetes based on modifying stem cells in the gut. People with type 1 diabetes are unable to regulate their blood sugar because their immune system destroys beta cells in the pancreas, which secrete insulin. The disease can be treated with insulin injections, but it is hard to mimic the body's precise regulation of insulin levels in response to glucose.

What's needed, says Anthony Cheung of enGene, a biotech company in Vancouver, Canada, is a type of cell that is sensitive to glucose and which can be engineered to produce insulin. K cells, which are found in the upper part of the small intestine, are good candidates as they produce a hormone called GIP in response to glucose in the gut. GIP sends a message to the pancreas that food is coming, priming the production of insulin. If K cells could be engineered to produce insulin themselves, they would cut out the middleman and deliver the hormone when it is needed.

The problem is that individual

K cells live for only about a week before they are sloughed off into the gut. So enGene needed to deliver the gene for insulin to the stem cells that continually give rise to new K cells.

The company has now cracked this, using nanoparticles of a polysaccharide called chitosan, found in shrimp shells, to deliver the genes to the cells. The nanoparticles carry two loops of DNA called plasmids, one bearing the gene for human insulin, the other encoding an enzyme that can insert the insulin gene into a cell's genome. After a single dose of nanoparticles, animals produced human insulin for more than 130 days. "We're looking to move this into clinical trials by early 2009," says Cheung.

Because some stem cells are only accessible for modification during a narrow window of embryological development, a few groups are experimenting with in utero gene therapy to correct inherited diseases such as some forms of breast cancer. Jesse Vreccenak and her colleagues at the Children's Hospital of Philadelphia in Pennsylvania have modified the stem cells that form breast tissue by injecting lentiviruses that carry a marker gene into the amniotic fluid of pregnant mice. Eventually, this may enable carriers of the breast cancer genes *BRCA1* and *BRCA2* to bear children with healthy copies of the genes in their breast tissue.

Meanwhile, other researchers

"After a single dose of nanoparticles, animals produced human insulin for more than 130 days"

are working on ways to extract stem cells from the body, genetically modify them in the lab, and then return them to exert a therapeutic effect.

At the San Raffaele Telethon Institute, Alessandra Biffi and her colleagues are planning a clinical trial using modified bone marrow stem cells to treat metachromatic leukodystrophy, or MLD. This is a

DISEASES IN THE FIRING LINE

Gene therapists are now targeting stem cells to treat a range of diseases

BRAIN

LYSOSOMAL STORAGE DISEASES
Insert genes into bone marrow and neural stem cells to boost levels of therapeutic enzymes in the brain

BREAST

BREAST CANCER
It may one day be possible to modify breast stem cells in utero to correct defective *BRCA1* and *BRCA2* genes

LUNG

PULMONARY ARTERIAL HYPERTENSION
Modify endothelial progenitor cells to make them promote blood vessel growth and protect against future damage

HEART

HEART ATTACK

Modify stem cells from bone marrow to enhance natural "SOS signal" from damaged tissue and recruit more stem cells to the site of injury

UPPER SMALL INTESTINE

DIABETES

Use gut stem cells to produce glucose-sensitive cells that will also manufacture insulin

lysosomal storage disease (LSD) in which toxins called sulphatides build up in the brain, and nerves lose their insulating layer of myelin. Children with severe forms of MLD go into a steep cognitive decline and lose motor control, usually dying before the age of 10.

The disease is caused by defects in the gene for an enzyme called ARSA. In experiments on mice, Biffi's team has shown that stem cells from the bone marrow can be modified to boost the production of ARSA and correct MLD. The stem cells give rise to immune cells called microglia, which migrate to the brain. "You can really generate a shuttle for your enzyme into the nervous system," Biffi says. Early next year, she will begin recruiting children with severe MLD into a clinical trial of the therapy.

Biffi's colleague Angela Gritti is also concentrating on LSDs, but she is adding genes for therapeutic enzymes to neural stem cells, which can give rise

to new brain tissue. For some LSDs, Gritti believes they may need to modify both blood-forming and neural stem cells. "We also need a high degree of tissue repair," she says.

Neural stem cells also have some subtler therapeutic effects. Evan Snyder's team at the Burnham Institute for Medical Research in La Jolla, California, has delayed the onset of symptoms in a mouse model of an LSD called Sandhoff disease by injecting healthy human neural stem cells into the mice's brains. As well as providing the missing enzyme, the stem cells also had an anti-inflammatory effect, further protecting the brain.

While the idea of using stem cells to rebuild diseased tissues grabs most attention, Snyder predicts that their ability to deliver corrective genes and to protect other cells from damage will have a bigger impact in the future. "The low-hanging fruit are these molecular therapies," he says. ●

STEM CELL ENHANCEMENT

"People are excited about the potential of stem cells, but most approaches are not leveraging them to their maximum potential," says Madhusudan Peshwa of MaxCyte in Gaithersburg, Maryland. "We're not getting into the driving seat and getting the cells to do what we want them to do."

Many teams have attempted to use adult stem cells in regenerative medicine – to repair damaged tissue after a heart attack, for example – but their efforts have been hampered by problems such as cells dying before reaching their target or not differentiating into the correct cell type.

Now researchers are waking up to the idea of genetically modifying stem cells to enhance their natural attributes and gain a new level of control over them. In the case of heart attacks, stem cells from both skeletal muscle and bone marrow have been shown to repair tissue damage to some degree, either through differentiating into heart muscle cells or releasing chemicals that stimulate existing cells to repair the damage. To make this process more effective, Marc Penn at the Center for Stem Cell and Regenerative Medicine in Cleveland, Ohio, genetically engineered bone marrow stem cells to produce triple the normal amount of a signalling factor called SDF-1. This is an "SOS signal" also released by damaged heart cells after an attack and is thought to recruit repair cells to the damaged area.

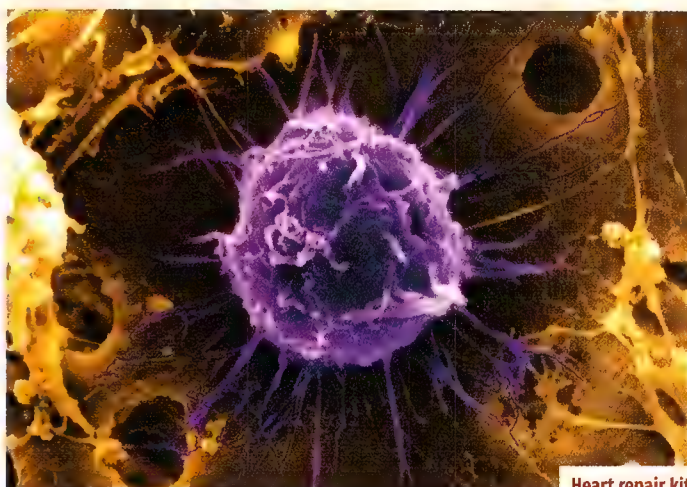
"The idea is to try and restart natural signals that initiate repair," says

Penn. When the cells were injected into rats' hearts after a heart attack, the team saw a 70 per cent reduction in heart cell death, compared with rats given unmodified stem cells (*The FASEB Journal*, DOI: 10.1096/fj.06-6558com).

Meanwhile, Duncan Stewart at the University of Toronto, Canada, is focusing on a more differentiated group of cells called endothelial progenitor cells (EPCs), to develop a therapy for pulmonary arterial hypertension (PAH). This is a fatal condition in which tiny blood vessels carrying blood to the lungs are destroyed. Previous studies have shown that EPCs can protect blood vessels against future damage, but Stewart's team wanted EPCs to repair damage to blood vessels after it had occurred.

Endothelial cells usually produce an enzyme called eNOS, which is thought to promote blood vessel growth and protect against cell death. Stewart's team inserted a circular piece of DNA containing the gene for eNOS into EPCs, and then injected the cells into rats with damaged lung vessels. The rats showed a significant improvement in blood flow to the lungs and more survived compared with untreated rats.

"EPCs by themselves seem to have some effect, but you can get much better effects if you push the cells in the right direction," says Stewart, who presented his results at Bio2007 in Boston last month. He has now begun a safety study of eNOS-modified EPCs in 18 humans with PAH. Linda Geddes



Heart repair kit

Teleportation, but not as we know it

ZEEYA MERALI

QUANTUM teleportation, evoking as it does images of Star Trek-like transporters, hasn't quite lived up to its promise. It has never managed to transport more than a few fragile photons over short distances. Now there's a system that can potentially teleport thousands of substantial particles – without any quantum hang-ups.

Teleportation usually refers to a process that relies on quantum entanglement, where two particles are linked regardless of the distance between them, so that any change to the state of one instantly changes its twin. However, entangled particles are difficult to prepare and delicate to handle, imposing severe limits on quantum teleportation.

Now physicist Ashton Bradley's team at the Australian Research Council Center of Excellence for Quantum Atom Optics in Brisbane is proposing a technique that avoids quantum entanglement entirely. "We're talking about a beam of about 5000 particles disappearing from one place and appearing somewhere else," says Bradley. "We feel that our scheme is closer in spirit to the original fictional concept," he adds. While the

technique can also transmit quantum information in the beam, the technique itself does not rely on the quantum properties of particles, so the team have dubbed the new method "classical teleportation".

They hit upon the idea by accident. "We were messing around with a way to sensitively measure the quantum properties of an atom beam when we realised we could efficiently use the technique to transport matter," says Bradley.

In their method, a beam of rubidium atoms is fired into a "sender" device, also made from rubidium atoms (see Diagram). At the same time, a "control" laser pulse is fired at the sender. This laser traps the incoming atoms from the rubidium beam, exciting them to a high energy state.

Normally, if the sender were made of ordinary matter, the incoming atoms would simply lose this extra energy by releasing photons in every direction. "This wouldn't be much use if you hoped to ever reconstruct the matter beam," says team member Simon Haine.

The team's set-up prevents scattering by making the sender from rubidium atoms in a special low-temperature state called a



Beaming up looked so darned easy

Bose-Einstein condensate. In a BEC, all atoms are in their lowest possible quantum state. "When a bunch of new atoms from the matter beam hit the BEC they want to join them in this lowest state, but they can only do that by shedding all their extra energy as photons released in a very directed pulse," says Haine.

This outgoing "messenger" pulse of light can then be transmitted down an optical fibre, carrying with it all the information about the original matter beam, including the number of atoms it contained, their momentum and energy, and quantum properties such as their phase. "The only limitation on how far this messenger pulse can

travel is the length of the optical fibre," says Bradley. "We're transmitting the information at the speed of light."

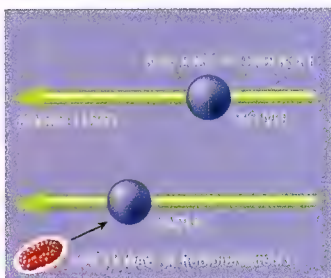
In theory, the original matter beam can then be reconstructed at a distant location when the messenger pulse strikes a BEC "receiver", which is controlled by a second laser pulse. The team's calculations show that once the messenger pulse hits the receiver its atoms are excited and they eject a second matter beam with identical properties to the original (www.arxiv.org/abs/0706.0062).

John Close, an expert on atomic laser physics at the Australian National University in Canberra, is impressed. "Using entangled atomic states looks pretty tough in comparison." Close wants to set up an experiment to test the system, but estimates it will take at least four years.

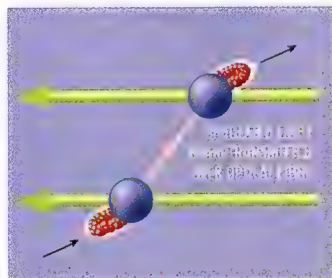
Warwick Bowen, an expert on quantum optics at the University of Otago in New Zealand, believes the method will be useful for setting up networks of quantum computers. "This is a system that can transfer the state of an atomic system to an optical system and then back to a second atomic system – a key requirement of quantum information networks." ●

CLASSIC TELEPORTATION

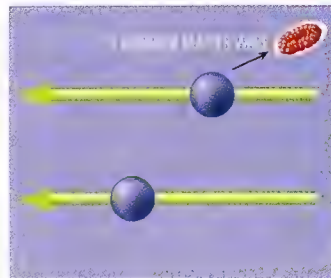
A matter wave made of rubidium atoms interacts with a "sender" – a Bose-Einstein condensate made of ultra-cold rubidium atoms



The matter wave is absorbed by the sender, which then emits a light beam containing all the information about the incoming matter wave



When the light beam enters the "receiver" – another Bose-Einstein condensate – the pulse is absorbed and the receiver ejects a matter wave identical to the one that entered the sender



SOURCE: ASHTON BRADLEY

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Sea lions face brain damage and death

Keeping tabs on toxic ocean threat

ARIA PEARSON, SANTA CRUZ, CALIFORNIA

ON A computer screen, the California coastline bleeds pools of vivid red. As I watch, some of the red swirls out into the open ocean and disappears, while some seeps ominously into bays and inlets along the shore. "You can see how the ocean is concentrating it and diffusing it," says Raphael Kudela, as he clicks the replay button.

The red stain is in fact a simulation of the emergence and movement of massive amounts of chlorophyll in the ocean, a telltale sign of an algal bloom.

Blooms of algae have long been a part of life in the waters off California, but in recent years they have become increasingly toxic, killing thousands of marine mammals and birds. Last month the region was hammered by a bloom twice as poisonous as anything it had seen before.

To understand why, Kudela, a phytoplankton ecologist at the University of California, Santa Cruz, has combined satellite images with information on ocean dynamics, such as winds and currents, to predict and track the toxic blooms. His models are now set to plug into a federally

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funded network currently in development that aims to provide a better understanding of what is happening in the waters off the west coast of the US. "The idea is to do for the ocean what the weather service has done for the land," he says.

Algal blooms are made deadly when photosynthetic diatoms of the genus *Pseudo-nitzschia* produce a powerful neurotoxin called domoic acid. This accumulates in fish and shellfish without apparent harm, but can cause seizures and death in marine mammals, birds and humans that eat them. The California Department of Health Services monitors the amount of toxin in mussels and issues warnings if levels rise above 20 parts per million. This year mussels were found with more than 600 ppm of toxin in their tissues, the highest on record.

"There's been a pretty dramatic change over the past six years," says Gregg Langlois, head of the state's monitoring programme. Domoic acid was first detected in California waters in 1991 and began appearing regularly in 2000. Monitoring efforts keep the poison from reaching humans, but seabirds are often killed in their hundreds when a toxic bloom erupts. Whales, dolphins, seals and sea otters are also affected, says Tracey Goldstein, a veterinarian at the Marine Mammal Center in Sausalito, California. Her centre deals with many sick sea lions that survive the initial poisoning but end up brain damaged following the seizures.

This year animal rescue centres were inundated with sick and dying animals after the record spike in domoic acid levels. The reasons behind the

increasing intensity of the blooms remain elusive, but many think human activity is to blame. Kudela's team has discovered that the diatoms produce toxin in response to increasing levels of urea and copper. Urea is a fertiliser ingredient widely used in California that enters the ocean in run-off, and copper is a

"A neurotoxin accumulates in fish and shellfish, causing seizures and death in mammals, birds and humans that eat them"

component of boat-bottom paint.

Other factors that can affect diatoms include rising temperatures and falling levels of silicic acid, which diatoms need to build cell walls. "There are so many ways to make them toxic," Kudela says. He hopes to predict where and when a bloom is likely

to become toxic and how bad it will be. The information will help health officials and animal rescue teams organise their efforts.

The challenge for Kudela is learning to distinguish the toxin-producing organism from other phytoplankton, using satellite images alone. His computer models will soon feed into the Ocean Observatories Initiative, a \$330 million project that will integrate and disseminate information gathered continuously about the ocean. This will include wind speeds taken from buoys, currents measured with radar, and data from autonomous vehicles, hydrophones and seismic stations – all made available in near real time. "It's about getting the information in one place so you don't have to call up 15 people to find out what's going on with the ocean," says Kudela. ●

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NS070P08

'Junk' DNA makes compulsive reading

ANDY COGHLAN

THE central dogma of genetics could hardly be simpler: DNA makes RNA makes protein. Except that now this tidy picture of how genes work has been muddled by a mammoth investigation of human DNA.

It turns out that DNA generates far more RNA than the standard dogma predicts it should – even some “junk” DNA gets transcribed. The Encyclopedia of DNA Elements (ENCODE) project has quantified RNA transcription patterns and found that while the “standard” RNA copy of a gene gets translated into a protein as expected, for each copy of a gene cells also make RNA copies of many other sections of DNA. None of the extra RNA fragments gets translated into proteins, so the race is on to discover just what their function is.

“One of the critical questions is whether they’re important or not, and we simply don’t know,” says Ewan Birney, head of genome annotation at the European Bioinformatics Institute in Cambridge, UK, and analysis coordinator for the ENCODE project, which involves many labs from around the world.

Birney says that while the central dogma still holds, the discovery of so much extra RNA could mean there are hitherto unrecognised subtleties of gene regulation that now need to be explained. “It’s no longer the neat and tidy genome we thought we had,” says John Greally of the Albert Einstein College of Medicine in New York City.

ENCODE labs analysed 30 million bases or “letters” of human DNA – about 1 per cent of the total – covering 44 different and randomly chosen sites in our genome, and measured the

associated RNA transcription in living cells. The whole sample was analysed independently by a range of methods in 38 labs, then cross-checked.

With around 400 known genes in the chosen sample, researchers expected an equal number of different RNA transcripts according to the central dogma of one RNA copy

“The extra RNAs may help transport molecules around the cell or fine-tune and modulate the activity of the genes”

per gene. Instead, they found about twice the predicted quantity of RNA transcripts. Moreover, they also found almost 10 times the expected number of gene switches – the points in DNA where transcription can be activated (*Nature*, vol 447, p 799).

Many of the RNA transcripts were copies of sections lying across genes and their adjacent

stretches of “junk” DNA (see Diagram, below). Even more surprising, many transcripts were copies of junk DNA situated further from genes. The researchers speculate that the unexpected glut of gene switches might explain the extra RNA.

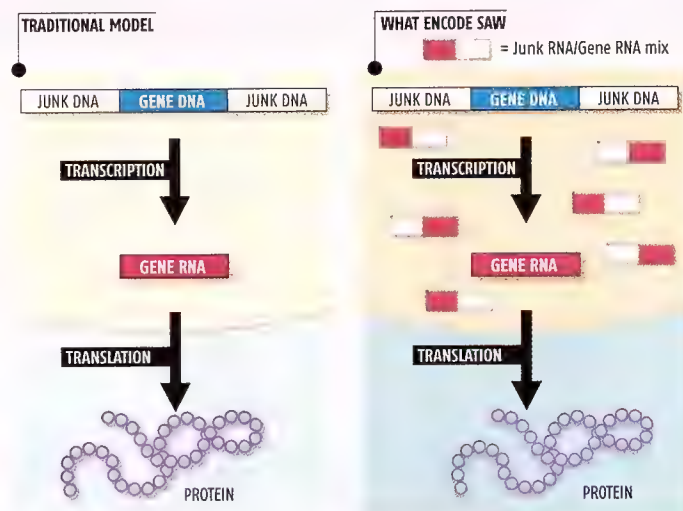
Birney says that the additional switches may be mutations that appear by accident and then generate new slugs of RNA, but because they are produced randomly, most are evolutionarily neutral “passengers” in the genome. There might be rare occasions, however, when a new RNA does confer an advantage.

Tom Gingeras of genomics firm Affymetrix in Santa Clara, California, and a co-leader of ENCODE, disagrees. He first reported transcription of non-coding DNA three years ago (*New Scientist*, 21 February 2004, p 10), and is convinced that the extra RNAs have a function, perhaps to help transport molecules around the cell or fine-tune and modulate the activity of genes themselves. “We don’t think they’re produced by accident,” he says.

Whatever the truth, the results pose fresh puzzles about how genes work. “It would now take a very brave person to call non-coding DNA junk,” says Greally. ●

A ROLE FOR JUNK

In the traditional view “junk” DNA was not thought to be transcribed into RNA. Now the ENCODE project has found that it is, but no one is sure what function the resulting RNAs perform



THIS WEEK 50 YEARS AGO

TB vulnerability in our genes

The dramatic decrease in the number of deaths from tuberculosis which has occurred in this century is unfortunately not matched by a comparable fall in the number of people who contract the disease. Thus, in spite of highly effective new methods of treatment by means of drugs and surgery, tuberculosis remains a major medical problem, with 50 million cases in the world each year.

However, now that treatments are available to counter this disease and many people recover from it, it is becoming apparent that there is an important factor affecting the incidence of tuberculosis and its severity in different individuals, including their ability to fight the disease. It is clear that this factor is genetic, and passed down from generation to generation. A study by Dr J. F. Kallmann, who has traced the medical history of large numbers of twins in New York, has provided definite evidence that the course taken by the disease after infection is almost completely determined by heredity. When the twins came from a single egg – that is, they were genetically identical – the disease always took the same course in both patients. Especially, it was rare for one twin to survive the disease if the other did not. That these similarities were not due to identical environments was proved by the fact that twins from two eggs (and therefore not genetically identical) did not show the same concordance, although they were just as likely to have shared similar environments as genetically identical twins.

Genetic factors may be important in other infectious, deadly diseases too but, as in the case of tuberculosis, they only become apparent when effective methods of treatment allow enough people to survive to make it possible to recognise differences in response.

From *The New Scientist*, 20 June 1957

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MUSEUMVICTORIA

In brief



One tequila, two tequila, three tequila, biodiversity floored

DRINK too much tequila and you may lose your marbles, but a huge appetite for the drink is killing off more than just brain cells: intensive cultivation of its main ingredient, *Agave tequilana*, is harming the genetic diversity of other agave species.

Not only that, says Patricia Colunga of the natural resources unit at the Centre for Scientific Investigation in Yucatan, Mexico, but the area available for traditional food crops is falling, and the intensive farming is leading to soil erosion. Colunga and colleague Daniel Zizumbo

interviewed farmers from areas south of Jalisco state, and across Tequila-Amatitan, regions of west-central Mexico that are important sources of agave plants. They asked about the types of agave grown, and collected samples of plants (*Biodiversity Conservation*, vol 16, p 1653).

"South of Jalisco is the nucleus for the greatest diversity of traditional varieties of agaves in west-central Mexico," says Colunga. "The diversity and the traditional products that it supplies are part of the cultural heritage of Mexico and should be conserved."

The farmers said that traditional agave varieties can be grown with staples such as maize, beans and squash without recourse to herbicides, but *Agave tequilana* is grown in monocultures that require the use of herbicides.

Twice your height, armed with claws

IMAGINE an ostrich that tipped the scales at 1400 kilograms, standing twice as tall as a human, with a solid tail and massive body, plus long, feathered arms with sharp claws, and a turtle-like beak. That's how a newly discovered dinosaur called *Gigantoraptor* looked as it roamed what is now China about 80 million years ago.

The huge size of *Gigantoraptor* is a surprise because it is a

member of the oviraptorids, a group of flightless feathered dinosaurs closely related to birds, which mostly weighed less than 40 kilograms. Known since the 1920s, oviraptorids were toothless and probably omnivorous. "*Gigantoraptor* would be a strange animal in any environment," says Tom Holtz of the University of Maryland in College Park.

The partial fossil skeleton was found in Inner Mongolia and is from a young adult about 8 metres long. Many of *Gigantoraptor*'s features are unique, suggesting dinosaurs were more diverse than has been recognised, says lead author Xu Xing of the Institute of Vertebrate Paleontology and Paleoanthropology in Beijing (*Nature*, vol 447, p 844). Its combination of slender limbs and long lower legs may have made it the fastest runner among large two-legged dinosaurs, he says.

Scaredy-birds

ARE cats frightening birds so much that they don't breed? Andy Beckerman and colleagues from the University of Sheffield, UK, think fear of cats may explain the ongoing fall in urban bird numbers.

Many accusatory fingers point to the cat, and in areas of high cat density, predation may indeed be the sole reason for the decline. It might not be cats' only effect, however. Beckerman's team built a model that took both kills and the fear factor into account, and found that apprehension could explain the decrease even where predation is low. A reduction of just one chick per breeding pair per year per cat can lead to a fall in bird numbers of up to 95 per cent (*Animal Conservation*, DOI: 10.1111/j.1469-1795.2007.00115.x).

"What's cool about the model is that with no mortality you still get a large decline through mechanisms of fear," says Beckerman.

Starry duo dance into record books

THE two most massive stars ever found are circling each other 20,000 light years away near the centre of the Milky Way.

Anthony Moffat of the University of Montreal in Canada announced the discovery of the binary star system, called A1, last week. Even the smaller of the duo, at 84 solar masses, is bigger than the previous record holders. The larger weighs 114 solar masses.

"I'm astonished and very curious," says astrophysicist John Brown of the University of Glasgow, UK. "I didn't think stars that big could exist – they should blow themselves to pieces." That's because the more massive a star, the more radiation it generates inside its core, which increases the pressure on the star's outer layers until it eventually explodes.

Mars's uphill ocean explained

THE case for an ancient ocean on Mars just got stronger.

For years scientists have been baffled by what look like shorelines on Mars. But, impossibly, sea level appears to have been 2.5 kilometres higher in some parts than in others – so many have doubted the ocean really existed. Now Taylor Perron of the University of California, Berkeley, and colleagues think that massive wobbles in the planet's rotation may explain the mystery.

Working with a mathematical model of Mars, the team found that volcanic eruptions and asteroid impacts could have caused the planet's poles to shift in the past, a phenomenon called true polar wander (*Nature*, vol 447, p 840). A side effect of this would have been large-scale deformation in the crust, accounting for the strangely varying coastline heights.

If correct, the team's findings make it likely that a body of water once covered one-third of the Martian surface – about the size of the Pacific Ocean – near the equator, then later migrated into the northern hemisphere as the poles shifted. "We've turned what has been a monkey wrench for us into a piece of evidence that supports the idea there were oceans on Mars," says Perron.

The final piece of the puzzle, he adds, will be finding how enough water to fill the basin is now buried in the crust. The basin has been dry for at least the past 2 billion years.



Injection of brain cells offers hope for Parkinson's

STEM cell therapies for human brain diseases may have come a step closer, after monkeys with symptoms of Parkinson's disease showed marked improvement following a single injection of neural stem cells.

To recreate the symptoms of Parkinson's in African green monkeys, Richard Sidman of the Harvard Institutes of Medicine in Boston and his colleagues injected them with a chemical that damages neurons that make dopamine, a neurotransmitter vital for controlling movement.

They then injected the monkeys' brains with neural stem cells from human fetuses that had been miscarried at 13 weeks. A month later, the monkeys showed marked recoveries. "They could stand, walk, feed themselves, and had regained independent living," says Sidman.

After around four months, the animals began to deteriorate, probably because the cells were being attacked by the monkeys' immune systems. However, they were still much healthier than untreated monkeys (*Proceedings*

of the National Academy of Sciences, DOI: 10.1073/pnas.0704091104).

Post-mortems showed that the implanted cells had dispersed throughout the brain to structures where dopamine is produced. Their primary role seemed to be in protecting the brain against further damage, rather than replacing damaged cells, as had previously been assumed.

The team now plans to see if immunosuppressive drugs and repeat injections can prolong the benefits over the longer term.

It pays to shoot the messenger

INTERFERING with our genetic machinery could prove an effective way to fight leukaemia.

The form of the disease called chronic lymphocytic leukaemia (CLL) is characterised by large numbers of abnormal white blood cells triggered by over-expression of a gene called *Bcl-2*. So Santaris Pharma of Hørsholm in Denmark has developed a drug that switches off *Bcl-2* by binding to its messenger RNA (mRNA) strands and destroying them before they can be translated into protein; this is called RNA interference (RNAi).

Most RNAi-based drugs rely on double-stranded pieces of RNA to destroy mRNA, but these can be difficult to get into cells and often have to be injected locally. Santaris has now created smaller single-stranded molecules termed "RNA antagonists", which cross cell membranes easily. This means they can be injected into the bloodstream, and so can be used in a broader range of diseases.

In early human trials, an RNA antagonist for *Bcl-2* led to rapid falls in the white cell blood count, without serious side effects. The results were presented at a meeting of the American Society for Clinical Oncology in Chicago last week.



Laughter is the breast medicine

FAMED for its restorative powers, it now seems that laughter also helps breast milk to fight skin allergies.

Breastfed babies with eczema experienced milder symptoms if their mothers laughed hours before feeding them, according to a study by Hajime Kimata at the Moriguchi-Keijinkai Hospital in Osaka, Japan.

He showed breastfeeding mothers either a feature length Charlie Chaplin movie or bland footage of weather information, and took samples of breast milk at regular intervals afterwards. Two milk feeds later, he also measured their babies' allergic

reactions to dust mites and latex. Those infants whose mothers had laughed had markedly reduced reactions (*Journal of Psychosomatic Research*, vol 62, p 699). All participating babies and some of the mothers suffered from mild atopic eczema – the most common type.

Kimata also found significantly higher levels of melatonin in the laughing mothers' milk. The hormone is associated with relaxation, and levels are reduced in people with eczema.

"It would be good to investigate if 15 minutes of laughter a day can reduce allergies in mothers and infants in the long term," says Michael Miller of the University of Maryland Medical Center in Baltimore, who studies the effect of laughter on heart disease.

Not mad or bad, just scared

Rather than brand children with the labels "ADHD" or "bipolar", professionals should pay more attention to the adults close to them, argues **Dorothy Rowe**

YOU are at home awaiting the arrival of the person on whom you feel your life depends. The person is very late. You try to watch TV but can't concentrate. You move from chair to window, from window to door. You make phone calls, check diaries, traffic news. A friend phones to chat, and you rudely tell them to hang up. The line must be kept clear.

You are exhibiting hyperactivity, impulsiveness, distractibility and emotional lability (instability and changeability). A psychiatrist with no context for your behaviour might say you have been stricken with attention deficit hyperactivity disorder, because the symptoms of ADHD look the same as the symptoms of fear. You, on the other hand, just feel afraid. Fortunately, as an adult, you articulate the reasons for your fear, and if the psychiatrist has any sense she or he abandons the diagnosis and pours you a stiff drink.

ADHD is not a diagnosis most mature adults face. Children, on the other hand, are being diagnosed with it in their millions. In the US nearly 4 million people, mostly children and young adults, are being prescribed amphetamine-like drugs for ADHD (*New Scientist*, 1 April 2006, p 8). The number of children diagnosed with bipolar disorder has also risen astronomically, according to child psychiatrist Gabrielle Carlson and colleague Joseph Blader at Stony Brook University, New York. They say that while in 1996 just 13 out of every 100,000 children in the US were diagnosed with bipolar disorder, by 2004 the figure had leapt more than fivefold to 73 in 100,000. They also showed that of children diagnosed with a psychiatric condition in 1996, 1 in 10 were bipolar, compared with 4 out of 10 in 2004 (*New Scientist*, 19 May, p 6).

Now here's a thing. Among the symptoms of bipolar disorder are hyperactivity, irritability (not getting your own way), psychosis (grandiosity/inflated self-esteem), sleep (lack of), elation (expansive mood) and rapid speech. These symptoms are an



exaggeration of ADHD. The young patients are very afraid.

In dealing with fear, we tend to follow one of two patterns. Some of us go quiet: we try to keep emotions under control, to think about what's happening and form a plan for dealing with the fear. That plan might not be realistic or sensible, but it's a way of trying to control things. The rest of us use action to deal with our fear.

Movie and TV duos often feature a thinker and an action man – say, Spock and Captain Kirk – who work effectively together. When the fear becomes serious, Spock retreats into his private world, while Kirk becomes increasingly and less usefully active. Spock might not always approve of his thoughts and feelings, but he is not afraid to go into this inner world. Kirk claims to value his emotions, but in fact is only prepared to acknowledge those he finds admirable. He denies fears, hatreds, jealousies, resentments because he fears them. He tries to outrun his inner world by being busier and busier, but of course he fails.

Few of the psychiatrists who hand out diagnoses of ADHD or bipolar have had long, detailed conversations with the children. More likely, their decisions were based on the children's behaviour in the consulting room, or described by parents and teachers.

There is another reason why doctors fail to see that these are the symptoms of great fear. Like adults, children fear many things, but one thing all children fear is adults. There is a vast body of literature on the effects of adults on children for good or ill: it is summarised in *Psychopathology and the Family*, edited by Jennifer Hudson, and Ron Rapee of Macquarie University in New South Wales, Australia.

We all have the power to hurt a child, and many of us do. Even loving parents and kind teachers know they may inadvertently frighten a child. If a child continues being afraid, she or he won't function normally, learn, or be happy. The people responsible for that child's welfare won't be doing their job properly if they don't reassure them.

In saying this I have broken a powerful rule: namely, that parents and those in loco parentis must not be criticised. If a child behaves badly, the child is at fault. If she or he can't be regarded as naughty and be punished, she or he must be mad, and the madness treated with drugs, the effects of which on the developing brain are still largely unknown. Blaming and punishing the child is also a ubiquitous cultural practice. In her book *Thou Shalt Not Be Aware*, the psychoanalyst Alice Miller noted that the Bible has stories of children sacrificing themselves for their parents, but none of parents sacrificing themselves for their child.

Diagnosing children with ADHD or bipolar disorder requires collusion. Parents and doctors must agree the fault is in the child. So parents fail to mention their own economic, social or personal problems, or underplay them, while doctors don't ask because they lack the skills and resources to help the parents. Thus parents can go on believing they are good parents faced with an inherently flawed child, and doctors that they are good doctors. The child continues to be afraid. ●

Dorothy Rowe is a psychologist and writer. Her book *Beyond Fear* is published by HarperCollins

"Even loving parents and kind teachers know they may inadvertently frighten a child"

Andrzej Krauze is currently showing his drawings at Shandy Hall, Coxwold, North Yorkshire, UK. The exhibition runs until 29 July 2007

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Vaccine options

From Peter Dunnill and David Fedson, University College London
Commenting on the stand-off between Indonesia and the World Health Organization over the provision of H5N1 bird flu virus samples (26 May, p 5), you touch on the even bigger issue that 90 per cent of the world's population, rich or poor, have no chance of receiving a conventional influenza vaccine. Global production is too limited.

However, by switching flu-vaccine facilities to produce a live attenuated vaccine, already approved and used for seasonal flu, the required number of doses could be produced. Furthermore, switching just a quarter of the world's biopharmaceutical protein production plants to produce a new protein-based vaccine – now close to clinical approval – will allow a greater speed of coverage, which is critical. Such switching is not commercially attractive, however, so action by governments would be needed.
London, UK

Find more ore

From Jonathan Cardy
I was rather unimpressed with the article on the threat to the world's mineral resources (26 May, p 34). Haven't we been hearing similar cries of "wolf" for 40 years?

Surely if a mineral becomes scarcer the price will rise: currently uneconomic deposits will become economic to extract; more will be recycled; and in some cases alternative materials will become cheaper than the scarce resource.

I would have been more interested in a discussion of current extraction technology and the geology involved. Do we have a random distribution of minerals, with ore becoming vastly more available if we are prepared to exploit lower grades? Or are the currently viable deposits the bulk of the likely

resource? Have we surveyed all of the Earth's mineral resources, or are there still countries where potential resources are unknown? What is the potential for recycling, especially as prices rise?
Teddington, Middlesex, UK



From Gordon Stanger

We may be a little short on rhodium, indium, gallium and germanium, but the rest of the feature was just ill-considered scaremongering. It's not a question of "running out", but of "how much are we willing to pay?" We have enough real problems to face without conjuring up illusions of scarcity.
Hallett Cove, South Australia

Warming proof

From Douglas Dickie

Guy Cox makes an extremely important point in implying that the burden of proof regarding the truth of global warming lies with the sceptics, not those wishing to reduce carbon dioxide levels (2 June, p 26). Sceptics and believers alike accept the fact that humankind has increased CO₂ levels substantially since the industrial revolution. Likewise, both must accept that very simple chemistry teaches us that CO₂ is a greenhouse gas and, other things being equal, increasing CO₂ levels will warm the world.

Unless it can be demonstrated unequivocally that other things are not equal, and some mechanism exists which is acting to stabilise planetary

temperatures, the human race is duty-bound to assume that it must keep CO₂ levels as near as possible to those which prevailed in the recent past.
Aberdeen, UK

Grasp the meaning

From Bo Jin, Southern Yangtze University
Jonah Lehrer reports the finding that the experience of synaesthesia may be triggered not by sensory inputs but by concepts (19 May, p 48). I am not a neuroscientist but a practitioner of cognitive linguistics and was excited, not so much by the crosstalk between linguistic concepts and sensory experiences, as by the support this gives to an established paradigm in cognitive linguistics: that concepts are embodied. George Lakoff, a pioneer in cognitive linguistics, has long claimed that concepts are generally based on our bodily experience, such as action and perception.

For example, in "I have a full grasp of the whole passage", the word "grasp" is used metaphorically. But this sense is not an out-of-thin-air thing, but rather based on its physical sense as in "I grasped an apple". The concept of "understanding" seems to be connected with the concept of "grasp". This relationship is also evidenced in Chinese.

More recently, research on mirror neurons has lent more compelling evidence to this Lakoffian approach: for example, neurons involved in executing a monkey's action also fire when the monkey merely sees an experimenter perform that action. Similar experiments have been done on human subjects with action and auditory stimulus. There are also tentative findings on correlations between action-execution, hearing the action word with its literal meaning, and hearing the action word with a figurative meaning.

The research of Julia Simner covered in your feature is part of a bigger picture of embodiment incorporating relationships between sensory experience, physical concepts and abstract concepts in people with synaesthesia.
Wuxi, China

Clash of world views

From Thomas Shipp

Whatever else the Answers in Genesis group might be accused of, Lawrence Krauss's charge of intellectual dishonesty in their use of the fruits of science and technology is misplaced (26 May, p 24).

The science of technological devices such as planes, cars and TVs is based on what we can observe and test directly in the same time frame in which they operate. The science of reconstructing the origins and history of biological systems, the Earth and the cosmos is not based on what we can see (still less test) at the time of their origin. It is based on how we interpret – in the light of our preferred world views – what we see today of the fragmentary and time-altered leftovers of years gone by.

The fact that one scientific methodology works well when applied to the regularities of nature, by explaining how things operate, is no guarantee that it will work well when applied to irregularities in nature or to explaining biological origins. A methodology adopting a world view which presupposes that everything can be explained wholly in terms of the regularities of nature will very probably be successful where things do indeed operate in accord with such regularities. However, where in fact they may not so operate or originate, such a restricted approach will be science-stifling and potentially misleading.

Therefore, even if we don't agree with creationist methodologies (which I don't), they are not being intellectually

- Find more ore
- Darwin awards
- Firestorm theorists

dishonest by embracing indisputably science-based technology whilst rejecting disputable science-based "origins" history.
Plymouth, Devon, UK

Accident prone

From ManMohan Sohdi,
City University London

A better question to ask than "do some people have bad luck?" is whether a past history of accidents provides any forecast of accidents (12 May, p 19).

Consider this thought experiment, using similar figures to the study you report. Ask 147,000 people to toss a coin, say, 20 times.

There will be a "hapless" group near one end of the spectrum with 50 per cent more tails on average than the people outside this group. However, if we consider future coin tosses, there are no people who are more prone to tails than others.

As regards accidents, it is possible that some people are more prone to accidents than others, but the article says that "the study doesn't reveal which people in particular are most at risk".

It is possible that the study draws spurious conclusions from completely random data. The conclusions then would be laughable except for the insidious possibility that an insurance company could cite such "research" to increase premiums for random accident victims.
London, UK



Chaos not free

From Andrew Yake

Bluntly put, it is absurd to imply, as you report Björn Brembs doing, that chaos is a "rudimentary sort of free will" (19 May, p 16). This chaos is in fact a sort of determinism, which is antithetical to the strong sort of free will and irrelevant to the weak one.

The strong sort is known as origination: the assertion that decisions can be originated by the free will of an agent such that those decisions have no causes.

Thus, as an "uncaused" source of causation, origination is the province of faith, and its existence is widely doubted by scientists and philosophers alike.

The weak sort, called voluntariness, merely asserts that an agent has free will if it can behave in a way that suits its own preferences.

Arguably the most familiar conception of free will, voluntariness reduces to subjectively experienced freedom of choice.

Consequently, it can only be ascribed to entities believed to possess sufficient subjectivity. While voluntariness is easily constrained, by imprisonment for example, few doubt its existence.

The mathematically defined chaos to which Brembs refers cannot provide evidence for free will as voluntariness, because it tells us nothing about internally experienced freedom, or any other aspect of subjectivity.

The verified presence of mathematical chaos actually excludes free will as origination, because by definition this chaos conforms to a predetermined pattern, while origination admits no predetermination.

Conflating origination with voluntariness is a common error in unsophisticated discussions of free will. Suggesting that deterministic chaos is evidence for any conception of free will, however, propagates far worse confusions.

Pittsburgh, Pennsylvania, US



Obnoxious children

From David Ransen

Your article on bipolar disorder omitted discussion of the dreaded JOD (Juvenile Obnoxiousness Disorder), whose incidence is growing at alarming rates (19 May, p 6). The symptoms closely resemble those included in the official DSM-IV definitions of bipolar disorder and attention deficit hyperactivity disorder.

Although JOD has been successfully treated for millennia by familial love, patience and discipline, the sudden rapid spread of this serious disease must now be aggressively treated with psychotropic drugs. And preferably off-label drugs, at that: those intended for something else that generally haven't been tested on children and that are known to carry serious and potentially lethal side effects when given to adults. The alternatives are too horrible to contemplate.

How fortunate we are that big pharma does not need to conduct new research into JOD, because they already have ample supplies of drugs developed and approved for the treatment of adults with other diseases, such as epilepsy and schizophrenia.

As reported in your article, Harvard psychiatrist Michael Miller says that "we simply don't have all the information we need to connect the dots between behaviour, causes and symptoms". The lack of scientific knowledge has never stopped us from administering powerful drugs, off-label, to adults, so why not do the same to children?
Boca Raton, Florida, US

Hide in plain sight

From Harry Dewulf

Apparently Microsoft is developing techniques to guess personal information from your web-browsing history (19 May, p 32). My reaction was to write a tiny program I've called "Chaff".

It navigates to www.newscientist.com and selects three words at random, then uses a famous web search engine to look them up. It then visits one of the first three results, stays there a random number of seconds and returns to the search results page, where it selects another page at random and repeats, periodically selecting three more words from a new page.

The aim is to produce a superficially real-looking browsing history – the chaff – that would be horribly difficult to separate from the wheat of my real browsing, without creating any serious nuisance. Chaff could be further tuned to match aspects of my own browsing behaviour.

This all follows from the observation that the secret to concealment is not to hide a needle in a haystack, but to build a stack of needles and hide it there.
Houdelaincourt, Meuse, France

For the record

● We described Robert Weinberg of the Whitehead Institute for Biomedical Research as being a "winner of a Nobel prize for his work on viruses and cancer" (2 June, p 38). He has not won the Nobel prize.

● Gordon Gekko may be a fictional character from the 20-year-old movie *Wall Street*, but we should not have used a fictional spelling of his name on our cover (2 June).

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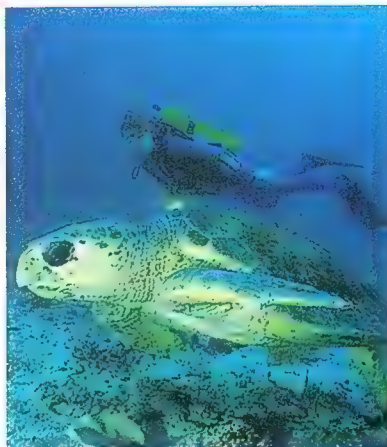
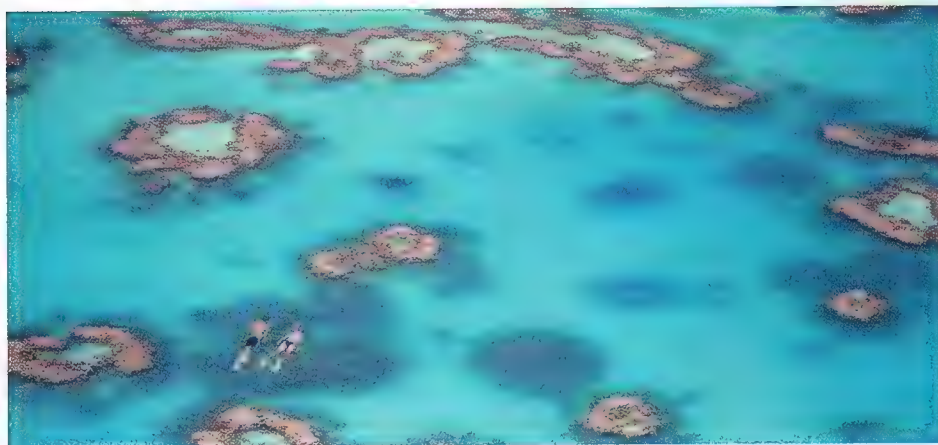
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Technology

AN EYE FOR OVEN CLEANER

"Look up, I'm just going to drip oven cleaner into your eye."

If you heard this from your doctor, you would probably run screaming from the consulting room. But drops containing a substance commonly used to polish glass and remove grease could be used to treat glaucoma.

Sudipta Seal at the University of Central Florida in Orlando was testing cerium oxide nanoparticles, or nanoceria, for use as a catalyst to remove grime from oven walls, when he realised they might have medical applications. "Before using any nanoparticles we have to check for toxicity," he says. Surprisingly, not only did nanoceria not irritate the eyes of rats and rabbits, in some cases they helped protect cells from light damage (*New Scientist*, 30 August 2003, p 16). "We realised that nanoceria might

make a good vessel for delivering drugs directly into the eye," says Seal.

Glaucoma involves an abnormal build-up of fluid inside the eye. Existing eye-drop treatments contain chemicals that don't attach to transport proteins very effectively, so only a small amount gets through the cornea. Now Seal and colleague Sanku Mallik have successfully combined nanoceria with a compound that blocks the hCAII enzyme, which is involved in producing fluid inside the eye (*The Journal of Physical Chemistry B*, DOI: 10.1021/jp067666l).

At around 10 nanometres wide, the nanoceria are the right size and shape to penetrate the cornea. "We hope to have a high concentration of the drug reaching inside the eye, also allowing us to cut down on the dosage needed," says Mallik.



Glaucoma damages the optic nerve

How to charge phones wirelessly

YOUR mobile phone may soon recharge itself in the same way it transfers information: wirelessly.

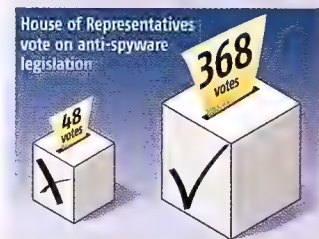
Marin Soljacic and colleagues at the Massachusetts Institute of Technology have previously used computer simulations to show that electromagnetic energy stored in one coil can be drained by another of the same resonant frequency (*New Scientist*, 18 November 2006, p 28).

Now the team has used the technique to transmit enough power across a room to light a 60-watt bulb. A current alternating at 10 megahertz passes through a coil linked to a capacitor, generating oscillating magnetic and electric fields. The fluctuating magnetic field induces a current in a receiver coil 2 metres away with the same resonant frequency (*Science*, DOI: 10.1126/science.1143254).



SNOOPS, KEEP OUT

US lawmakers have voted to make it illegal for spyware to load itself onto PCs without consent



Is there nothing they can't do?

FROM space elevator cables to television screens and fuel cell electrodes, there is scarcely an unclaimed application for carbon nanotubes.

Now microprocessor giant Intel wants to use them to extend the life of its chips. In a patent published last week (www.tinyurl.com/35hkar), Intel reveals how nanotubes' strength and

heat-dissipating properties can be used to reinforce the conducting copper tracks that connect millions of transistors together.

Inventor Chi-Won Hwang says depositing heat-sink nanotubes on electrically insulating layers adjacent to the copper tracks slashes the thermal stress caused by fast-pulsing electric currents. Such stress can cause tracks to fracture, rendering some chips useless. The super-strong tubes also boost a chip's resistance to impact shock, Hwang notes.

GIZMO

Still hungry after finishing a snack? Now you can eat the wrapper. Researchers at the US Agricultural Research Service in Wyndmoor, Pennsylvania, have made edible film by mixing the milk protein casein with water and glycerol, a sugary by-product of biofuel production. Peggy Tomasula used supercritical carbon dioxide as a solvent to extract the casein from milk and blend the ingredients together.

Gadgets could soon run on miniature acoustic heat engines. These devices conduct heat to a surface that warms the air around it. The movement of hot air generates a high-frequency sound wave that in turn vibrates a piezoelectric electrode, producing a voltage. Now Orest Symko at the University of Utah in Salt Lake City has built the smallest ever acoustic heat engine, at 1.8 millimetres wide.

"An endemic threat to privacy"

Human rights group Privacy International's description of Google, which came bottom in its privacy ranking of internet companies. The group criticised Google's incomplete privacy policies and the large amount of data it holds on its users. Google says it works hard to keep data private (BBC online, 11 June).

Murky trade in bugs plays into the hands of hackers

Finding bugs in software is big money – but what if the hackers are offering more than the good guys?

CELESTE BIEVER

WHEN computer security consultant Charlie Miller found a bug in the open-source software program Samba, he tried to sell it to the security firms or agencies who stood to lose out if hackers exploited the weakness. Trouble was, Miller found he had no idea how much it was worth.

As a result he had no way of knowing if he was being offered a fair price for the bug, which could potentially allow malicious hackers to attack any computer running Samba. He was also wary of handing over the information to potential buyers before a sale was agreed, with nothing to stop them stealing his intellectual property. "It was a very anxious time for me," says Miller, who is also a consultant for Independent Security Evaluators in Baltimore, Maryland. "I had worked hard, so I felt I deserved to be compensated."

What's more, the longer Miller spent trying to sell the bug, the greater the likelihood that a software firm would discover the same vulnerability and patch it, devaluing it instantly. A patched vulnerability is worthless as it poses a low security risk, whereas unpatched or "zero-day" bugs can fetch over \$100,000 (see Table).

Vulnerabilities form the basis of almost all malicious computer

activity. Hackers typically use these software "holes" to gain access to a victim's computer memory, where they can install spyware and files that spread viruses and worms, and press-gang the PC into "botnets" that

launch spam or denial-of-service (DoS) attacks. "Vulnerabilities are the raw materials of intrusion," says Eric Rescorla, a security consultant at Network Resonance in Palo Alto, California. They also pose a security threat to countries that rely on the internet for vital services and utilities such as banking and the power grid.

Encouraging researchers to hunt for vulnerabilities and report them before they are spotted by criminals is therefore crucial to the security of the internet, says Miller. "I think if you offer the financial incentive people will do this, and everyone will be more secure," he says. "But with the way things are, that's not necessarily going to happen."

There has long been a debate on the best way to ensure that firms like Microsoft and Apple find out about the worst bugs in their software and patch them before hackers move in. Until recently, "white hat" vulnerability hunters, motivated purely by the

kudos of discovering a flaw, would race the malicious "black hats" to find bugs and disclose them to the software firms, who could then develop patches (*New Scientist*, 25 June 2005, p 30).

However, software has become more complicated, making vulnerabilities harder and more time-consuming to find, so white hats have become less willing to work for kudos alone. As a result, a market in finding bugs has sprung up, with a cluster of firms such as Tipping Point of Austin, Texas, and iDefense of Sterling, Virginia, offering cash in exchange for zero-day bugs.

Tipping Point uses the information to update its anti-intrusion software, which blocks malicious code from entering its clients' networks. It then notifies the firm that made the software, which issues a patch to protect all computers running the program. Terri Forslof of Tipping Point says it has been responsible for patching 100 vulnerabilities since it launched its "Zero Day Initiative" almost two years ago.

Tipping Point does not disclose how much it offers for bugs, for fear of starting a bidding war that could inflate prices. iDefense has offered up to \$24,000 for specific bugs. But Andy Ozment, a computer security researcher at the University of Cambridge, says the going rate offered by these firms is typically between \$2000 and \$10,000. Miller warns that this isn't enough to persuade the best researchers to hunt for vulnerabilities. "There are not many people who are willing to do that work for that amount of money."

Sealing the deal is also risky for the bug hunter. To determine a price for the bug, which will depend on how dangerous the bug could be and which software it affects, the buyer needs to be able to examine it. For this reason, Tipping Point requires hunters to hand over all the information needed to find the vulnerability before it will make an offer. If the company then decides not to buy it, it vows to erase the

BUG BOUNTY

Governments, computer security firms and criminals are willing to pay more for revealing vulnerabilities and ways of exploiting them in secure software, or bugs that allow hackers to launch significant attacks

VULNERABILITY OR "EXPLOIT"	VALUE	SOURCE
"Some exploits"	\$200,000 – \$250,000	US government official referring to what "some people" pay
Significant, reliable exploit	\$125,000	Adriel Desautels of security firm Netragard, who brokers deals between security companies and bug hunters
Internet Explorer vulnerability	\$60,000 – \$120,000	Offered to security researcher H. D. Moore by a private buyer
Vista exploit	\$50,000	Raimund Genes at security firm Trend Micro discovered an auction site where hackers were hawking unpatched flaws to the highest bidder
"Weaponised exploit" (an attack against a vulnerability that can be fired against computers without requiring technical expertise)	\$20,000 – \$30,000	According to David Maynor at security firm SecureWorks
Zero Day Initiative; Purchases made by iDefense	\$2000 – \$10,000	According to David Maynor at security firm SecureWorks
Windows Metafile exploit	\$4000	Alexander Gostev at Kaspersky Lab in Moscow, Russia, discovered Russian hackers were selling the exploits
Microsoft Excel	\$1200	eBay auction site
Mozilla	\$500 + T-shirt	Mozilla bug bounty programme offering cash reward for vulnerability

SOURCE: CHARLIE MILLER



"The minefield of problems facing bug hunters may prompt some to turn to the black market"

in Germany. "Fixing bugs is only one way to achieve better software," he says.

The idea is that as things stand, software firms do not have enough incentive to develop more secure products because customers have no way to quantify how much more secure one program is than another. However, since bugs in more secure software fetch higher prices, a transparent market in vulnerabilities would provide an indicator of a program's security. Customers could use these prices to decide which products are more secure, encouraging firms to improve their software. "They need to know there is a return to having a more secure product," says Ozment.

This vision is a far cry from today's secretive market. More than a year after finding the Samba vulnerability, Miller eventually sold it to the US government for the respectable sum of \$50,000, he told a workshop on the economics of computer security in Pittsburgh, Pennsylvania, last week. However, one company offered him just \$10,000, and he still has no idea whether he received a fair price. "While the sale did happen, it was in spite of the market mechanisms in place, not because of them." ●

WHO WILL BUY MY BUGS?

Computer security researcher Charlie Miller sold the bug he had discovered in the open-source software program Samba to the US government.

Although there have been rumours in the past that governments buy vulnerabilities, this has never before been confirmed, says Andy Ozment, a security researcher at the University of Cambridge. It remains unclear how the government will use the information, but Ozment suggests it could help the

US to protect its financial and military infrastructure from cyber attack. "From my perspective, their motivation is to make sure the infrastructure is as secure as it can be," he says.

But bugs also allow countries to attack each other's infrastructure, so selling to governments raises ethical concerns, says Terri Forslof of Tipping Point in Austin, Texas, which buys vulnerabilities from researchers and then discloses them to software firms.

sell to the black market," says Miller. "But there are going to be some people who don't see it the same way."

Miller believes that matching the money available on the black market would persuade more hunters to sell vulnerabilities to computer security firms rather than to hackers. However, not everyone agrees. Forslof argues criminals will always be able to pay more for bugs than the computer security firms, as their returns are higher.

Government purchases could also be bad news for ordinary computer users. Once it had bought the vulnerability from Miller, the government did not disclose the information to Samba. As a result, the bug remained unpatched for a further nine months, during which time a hacker could have spotted the flaw and used it to attack computers. "There were nine months where I knew about it, but no one was protected from it," says Miller.

An alternative to outbidding the criminals is for companies to be more open about how much they are willing to pay. A market in which vulnerabilities are traded openly, with transparent pricing, would allow bug hunters to judge for themselves how much a flaw is worth before they try to sell it.

Ultimately this could also help to encourage firms to develop less bug-ridden software in the first place, says Rainer Böhme at Dresden University of Technology

information from its system, but Miller argues that many researchers are uncomfortable placing so much trust in a company. "I have no leverage at all" in that situation, he says.

The minefield of problems faced by bug hunters may even be prompting some of them to turn to the black market. Hackers are willing to pay high prices for vulnerabilities, as they can make a big profit from the spam and DoS attacks they are able to launch as a result. "I personally would never

The data-link backbone that we all possess

YOUR backbone's connected to your shoulder bone, your shoulder bone's connected to your neck bone – and your neck bone's connected to your cellphone.

Something along these lines is what Lin Zhong and Michael Liebschner at Rice University in Houston, Texas, envisage. They want to use the human skeleton to transmit commands reliably and securely to wearable gadgets and medical implants. Their research, funded by Microsoft and Texas Instruments, could also lead to new ways for people with disabilities to control devices such as computers and PDAs.

Wireless radio signals are already used to control gadgets and implants, but these can suffer interference from Wi-Fi and other sources. This makes them unreliable and, in the case of medical implants, potentially



Pleased to swap data with you

dangerous. They can also be hacked by anyone with an antenna, Liebschner points out.

So the Rice team decided to investigate using sound instead of radio waves. Bone is known to be a great conductor of sound, but so far it has only been used to transmit analogue signals in applications such as checking how bone is healing after a fracture, and in hearing aids that transmit sound from outside

the skull to the auditory nerve.

To see if bone could transmit digital signals over longer distances – to a headset, say, from a sensor worn on the wrist – the team applied a small vibrator to various parts of the body. When they then measured the acoustic signals received elsewhere on the body, they found that a “frequency shift keyed” (FSK) signal gave the best distinction between 0s and 1s. In FSK signalling a 0 is

represented by one frequency and a 1 by a different one.

They then measured how well bone conducted these signals when they were generated in places on the body where devices are normally worn: the wrist for watches, the lower back for cellphones worn on a belt, and behind the ear for headsets. They found the skeleton conducted even low-power vibrations from one location to another with surprisingly few errors. “This is quite amazing because all the links involved multiple bones and many joints,” Zhong told a conference on body networks in Florence, Italy, this week.

The researchers suggest applications such as a vibrator in a wrist receiver/transmitter that could tell an implant placed near a bone to release a drug dose, with the implant then sending back data from its sensors. Similarly, tooth clacks or finger clicks could be interpreted by a receiver to activate, say, functions in a phone.

For Liebschner, the great benefit is security. “All data transfer is contained inside the human body, and it can only be retrieved through direct physical contact,” he says. People could even swap information between devices via a firm handshake, Zhong suggests. **Paul Marks** ●

World's biggest holo-screen for your eyes only

IMAGINE playing an online game, only for the monsters you are battling to jump out of the screen and float in the air before you. That is the promise of an eye-tracking computer screen that generates a three-dimensional holographic video that

only you can see. At 50 centimetres across, the prototype screen, developed by SeeReal in Dresden, Germany, is the largest holographic video display ever built.

Holograms recreate all the light that would come from an object if it were really in front of you. A surface, or screen, diffracts light shone onto it to generate waves that interfere with each other to create the 3D effect. However, it takes considerable processing power to calculate how a screen should diffract light to produce a moving hologram viewable from any angle.

SeeReal's black-and-white prototype makes the calculations simple enough for an ordinary computer by using twin webcams to

track the viewer's eye positions. The system then generates two simple holograms that represent the object or scene from slightly different angles and projects them individually into both the viewer's eyes, producing the 3D result.

The hologram is generated by varying the position of liquid crystals to diffract light coming from LEDs behind the screen, while an array of lenses at the front of the screen directs the light towards the viewer's eyes. Users can explore the 3D environments using a mouse.

“Someone not being tracked by the system would see just a faint glow”

“Someone not being tracked by the system would see just a faint glow from the screen, but the viewer sees the whole scene,” says Hagen Stolle, lead developer of the technology. Adding more computing power to the prototype would allow more than one viewer to be tracked, or colour to be added, he says.

The greatest difficulty for anyone trying to build a holographic display is the mathematical complexity of generating moving holograms, says Adrian Travis, who works on display technologies at the University of Cambridge. “Tracking the viewer like this is a clever way to get around that.” Previous holographic displays have been around half the size of SeeReal's, he notes. **Tom Simonite** ●

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THE LAST PLACE ON EARTH...

What are the last true outposts on our planet? In an era when humanity seems to have subjugated the whole world, are there any places left untouched by human influence?

To find out, *New Scientist* set out to discover the Last Places on Earth. Pleasingly, there were plenty to choose from: unclimbed mountains, unexplored caves, unmapped deserts, tribes untouched by the outside world and islands where alien species have yet to invade. We also discovered the last place dinosaurs roamed, the last place to make radio contact with the rest of the world, the very last place that will survive when our sun expands – and many more. So join us on our grand tour of the planet's most unknown, pristine or downright extraordinary locations...

Tiny, icebound and uninhabitable, yet Hans Island is the subject of a bitter territorial dispute (page 45)

Oodaaq Island, the most northerly land on Earth – once upon a time (page 39)

The Acasta Gneiss is the oldest known rock formation on Earth (page 38)

Uunartoq Qeqertog, the first of many "warming islands" (page 39)

Dead dinosaurs walking (page 42)

A Mecca for explorers with scuba gear (page 40)

Last place to make "first contact" with civilisation (page 37)

Yungay, the only dry land on Earth without living things (page 41)

Last outpost against aliens (page 38)

Still undaimed by any nation state (page 45)



Vast, yet unknown until 1913
(page 39)

World's most threatened language
spoken here (page 41)

Not just unexplored, but almost
completely unknown (page 40)

Once a great seaside resort,
now the gateway to nowhere
(page 36)

Proof that the taste of capitalism
knows no bounds (page 47)

The final stronghold of
pictorial writing (page 44)

The highest unclimbed mountain
in the world. Chances are it will
never be conquered (page 40)

Bottom of the United Nations
heap (page 46)

Don't even try to go to North Sentinel Island
unless you want to die (page 37)

Last bastion of the Stone Age...
probably (page 37)

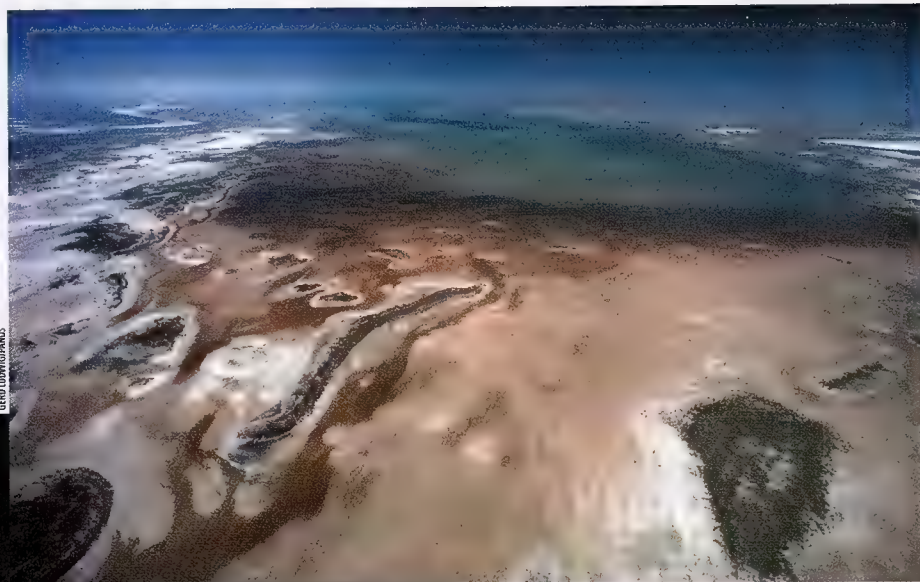
Swains Island, the last place
on Earth to make radio
contact with the rest of the
world (page 43)

Source of the most
ancient pieces of Earth's crust
ever found (page 38)

Here today, gone tomorrow
(page 45)

The Auckland Islands, the last habitable land
to be discovered by humans (page 39)

Better leave the planet before this thaws
(page 43)



GERD LUDWIG/PANOS

The remains of the former sea lie in a vast, unexplored and mostly unmapped desert.

STANDING on the promenade at Muynak in Uzbekistan, once one of the great seaside resorts of the Soviet Union, you don't see crashing waves, or boats sailing into the harbour that once supplied fish from Riga to Vladivostok. All you see is sand stretching to the horizon and beyond.

Welcome to what's left of the Aral Sea. Just 40 years ago this was the fourth-largest lake in the world, covering 68,000 square kilometres. Now almost all of it has gone, leaving 50,000 square kilometres of new, uncharted desert.

From Muynak, you can drive out a few kilometres to an "offshore" gas well. Along the way you pass dead trees left over from a failed attempt to afforest

1 ...to remain unmapped

a piece of the desert floor. There is also a line of telegraph poles, minus the connecting cable, and a canal carrying a dribble of farm drainage water. This is the last remnant of the ancient Amu Darya river, which once carried more water than the Nile and was the sea's main source of water. Now it simply trickles uselessly into the sand.

Until 1991, you could blame Soviet engineers. They turned the republics of Uzbekistan, Turkmenistan and Kazakhstan into a giant cotton farm that sucked up 90 per cent of the river's water. But nothing much changed when they went home. Today, the water is used to grow cotton for clothing sold in western shops.

Beyond where the road and the canal give out, there is nothing. On another continent there might be Bushmen, Aborigines or pioneer farmers who know every inch. Not here. Through binoculars I spotted a fox trotting through the scrub, but my vodka-swilling driver assured me that no people ever



...to make contact with civilisation

venture this way. Between us and the final, evaporating remains of the sea there was nothing but uncharted desert for 100 kilometres.

Afterwards I checked. Surely someone has been out here? I drew a blank with the Uzbek authorities, whose territory includes most of the former sea. They have deliberately turned their back on the place.

Satellites have snapped the new desert, of course. Much of it shows up brilliant white because of the huge salt deposits mixed with pesticides from the fields. A few foreigners have tried to drive across the seabed to confirm the satellite observations, says John Lamers, an agronomist at the University of Urgench in Uzbekistan, who keeps tabs on them. Most don't get far. "The bed is not completely unexplored, but only a very tiny little part of it has been surveyed," he says. The rest is terra incognita.

It cannot be long before someone decides that this new desert should be mapped and protected. It is, after all, unique. Fred Pearce



ON 3 March 2004, a group of 17 previously uncontacted Ayoreo Indians emerged from the jungle 100 kilometres north-east of Filadelfia in Paraguay. They were desperately thirsty, as cattle ranchers had muscled in on their territory and taken control of their water supply. The group reluctantly decided to approach some other Ayoreo who were setting up a new community in the last sizeable chunk of protected forest in the region and ask for their help.

This encounter may be the most recent example of what anthropologists call "first contact", but it certainly won't be the last. According to Survival International, which helps protect tribal peoples, there are still over a hundred tribes around the world – an estimated 40,000 people – who still have no sustained contact with outsiders.

How do we know such people exist? Usually it's from reports by missionaries, organisations like Survival International, government investigators or neighbouring tribes, who may have had fleeting glimpses of the people or seen telltale signs of fires.

For some, no contact is clearly the way they want it. One of the best known groups is the Sentinelese, a tribe of between 50 and 200 people who live on the tiny North Sentinel Island in the Andaman Islands. They have resisted contact for as long as anyone can remember, sometimes resorting to violence. In January 2006 they killed two fishermen who strayed too close to the shore, and when the Indian government sent a reconnaissance helicopter in the wake of the 2004 tsunami they fired arrows at it.

The Sentinelese are unusual in that they are the original settlers of the land they inhabit. Most people who resist contact are essentially refugees, fleeing to avoid loggers, oil companies, farmers, missionaries, drug traffickers or tourists.

Many of these communities are on the brink of extinction. In 1995, for example, FUNAI, the Brazilian government's Indian affairs department, made contact with the Kanoê people in Rondônia who were under siege from hostile cattle ranchers. There were only five left. Soon after, the Kanoê told FUNAI about another isolated group of six, called the Akuntsu, living nearby.

Sometimes the decision to make contact is taken by the tribe itself, as a last resort. In 1998 another Andaman tribe, the Jarawa, came out of the forest to visit settlements. It seems that pressure from poachers drove them to it.

According to Survival International, a tribe's population often plummets after first contact as a result of violence or disease. In the early 1970s, up to 80 per cent of the Panará tribe in Brazil were wiped out within 10 years of first contact. If they survive the initial shock they usually begin to grow again after 20 to 30 years.

Could there be any more uncontacted people out there that we don't know about? Perhaps. In January, FUNAI reportedly upped its 2005 estimate of the number of uncontacted tribes in Brazil from 40 to 67. In an aerial survey of West Papua, Indonesia, in 2002, missionaries reported sightings of over 40 tribes, but that's probably an underestimate. Large parts of the island of New Guinea have yet to be explored by outsiders because they are inaccessible or simply too dangerous.

So where might be the last place on Earth to make contact with outsiders? The depths of the Amazon or the forests in New Guinea are both good bets, but for the sake of the people themselves, let's hope first contact doesn't happen for a long time. Or better still, that it doesn't happen at all. Lucy Middleton

...with no invasive species

IF YOU saw the movie *Alien vs. Predator*, you'll know Bouvet Island as the ice-capped island in the Southern Ocean where extraterrestrials battle it out in an epic struggle for supremacy. How ironic, then, that Bouvet is likely to be the last place on Earth invaded by real aliens of a more dangerous kind.

One of the biggest threats to global biodiversity comes from invasive species transported from their natural habitats to places they don't belong. The movement began centuries ago, but the scale and speed of modern transport means the problem is no longer restricted to ship-borne rats and cats. Every sort of organism is on the move, hitching rides on ships, aircraft, cars and even people. Nowhere is safe, and while not all alien species run riot at the expense of the locals, their sheer number and variety makes it likely that some will. In the worst instances, alien invaders seriously disrupt local ecosystems and drive native species to extinction.

So where in the world is alien-free? Oceans offer a glimmer of hope: although the deepest trenches are no longer pristine, hydrothermal vents are almost certainly too peculiar to play host to foreigners. The frigid waters of the Southern Ocean have also managed to keep out would-be settlers from warmer waters, although global warming could soon put paid to that.

Land without aliens is another matter. The remotest parts of the Amazon rainforest and the least accessible regions of deserts might have escaped, but with people moving into ever more isolated parts of every continent it can only be a matter of time. That leaves just a few dots in the Southern Ocean vying for position as the last place on Earth untouched by aliens. Of those, the strongest contender is Bouvet Island. As well as being one of the least hospitable specks of land on the planet, it is the most remote. The nearest land, another uninhabited spot called Gough Island, is 1600 kilometres away.



Since its discovery in 1739, few people have been anywhere near Bouvet and those that ventured close rarely landed. Most of the island is covered in ice, apart from the sheer cliffs rising out of the sea. There is a lava shelf big enough for a few nesting seabirds and a thin strip of beach made of black volcanic sand, but no harbour or landing place. Bouvet became a Norwegian territory in 1927 and was declared a nature reserve in 1971, and apart from an automated weather station installed in 1977, humans have left little trace on it. The only visitors in recent years have been researchers and radio hams (See page 43).

For now, Bouvet's native species can breathe easy – not that there are many of them. The island's size, isolation and youth – it's less than 1.4 million years old – means the roll-call is brief: two mosses, three liverworts, 49 lichens, five mites and three springtails. No one has checked the nematodes or tardigrades, but that's all to the good. The fewer people who visit, the longer Bouvet will stay alien-free – assuming of course that there isn't an alien colony sleeping under the ice, biding its time until the next attack from outer space... Stephanie Pain

...to preserve a piece of Earth's original crust

FINDING a piece of original crust requires an epic journey to the frigid north, the scorching outback, or maybe even beyond the bounds of Earth itself.

The first stop on our odyssey is Yellowknife, capital of Canada's Northwest Territories. A journey 350 kilometres north of the city brings you to the Acasta Gneiss, a 4.03-billion-year-old outcrop that contains the oldest known rocks still firmly attached to our planet.

But we have long known that Earth is 4.56 billion years old, and that the crust solidified shortly afterwards. Are there any chunks of crust older than the Acasta Gneiss, or has plate tectonics obliterated all traces?

The answer lies in the Jack Hills of Western Australia. Amid rock formations 3.8 billion years old,

researchers have recently found small, tough minerals called zircons that have survived for some 4.4 billion years. These are the oldest known minerals anywhere on the planet.

That doesn't mean there aren't older ones around, however. "The amount of Earth's surface we've examined closely is vanishingly small," says Mark Harrison of the University of California, Los Angeles. "I think there are surprises still to come."

For those not willing to brave a journey to the ends of the Earth there may be an easier way to find super-ancient minerals – visit your nearest beach.

Because zircon resists weathering so well, small bits find their way onto beaches all over the world. On average, beach sand is between 0.03 and 0.04 per cent zircon. The vast majority of these grains will

be younger than those from the Jack Hills so it's unlikely that you will discover the world's oldest mineral. But you never know. "The chance is incredibly low," says Harrison, "but you can't win the lotto if you don't buy a ticket."

A more likely way to hit the jackpot is to take an even more epic journey – to the moon. Researchers believe the young Earth was regularly bombarded by asteroids and other impactors. Even small objects 100 metres in diameter could generate enough energy to fling pieces of crust out into space.

"There's virtually no question that somewhere there is a fist-sized rock older than anything we've seen," says Harrison. "And it's probably resting quietly on the lunar surface." The only snag is getting there. Michael Reilly

...to be discovered

YOUR name won't go down in history alongside Columbus or Vasco da Gama, but there is still undiscovered land to be found – if you know where to look.

Ever since modern humans evolved in east Africa 160,000 years ago, our species has been gripped by wanderlust. It took us only a few thousand years to discover and colonise Eurasia, and Australia and the Americas soon followed.

The last true pioneers were the Polynesians, who led the final wave of human migration across the South Pacific starting around 2000 years ago. The Polynesians' final landfall is difficult to work out, says Atholl Anderson, an archaeologist at the Australian National University in Canberra. Radiocarbon dating suggests that their most recent settlements were established between 600 and 700 years ago, but is not precise enough to decide which was the last. Anderson reckons the Auckland Islands, south-east of New Zealand in the coldest and most dangerous seas of southern Polynesia, are a strong candidate (*Antiquity*, vol 79, p 791).

However, these islands were by no means the last land on which humans set foot. The last continent

to be discovered was Antarctica in the early 1800s. Stepping down a level, the last unknown major land mass was Severnaya Zemlya, a harsh archipelago of polar desert off the coast of Siberia, discovered in 1913 and not fully explored until 1930.

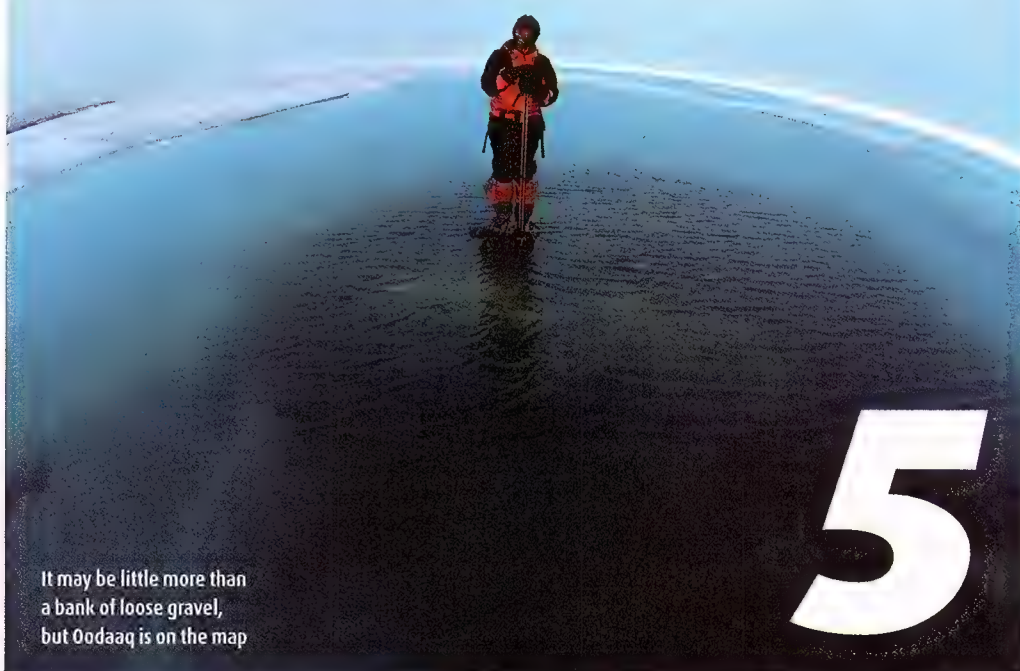
Closer to the present day, staking a claim for undiscovered land has obviously become trickier, especially because satellite imagery now covers every inch of the globe. But that hasn't stopped explorers from trying. In 1978, a Danish survey team reckoned they had found the most northerly land off the coast of Greenland, which they named Oodaaq Island. It was undoubtedly further north than anything else, but to define it as "land" was stretching it a bit. Oodaaq is a bank of loosely consolidated sand and gravel the size of a badminton court.

Or at least it was. In 1996, an explorer called Dennis Schmitt returned to the area and claimed he was unable to locate Oodaaq. However, he did find a similar mound nearby "emerging from the sea like a great rock whale". Unfortunately, that too had disappeared when he returned in 2003, but he found yet another one a few miles further north.

These gravel bars are temporary, says Henrik Højmark Thomsen of the Geological Survey of Denmark and Greenland. Loose material is pushed ahead of advancing glaciers during winter and left exposed as the glacier retreats. When the ice advances again, the new islands may be sheared away so are not generally recognised as new landforms. However, Oodaaq does appear on the most recent Danish National Survey maps.

Explorers wishing to put their name to somewhere more permanent should not abandon hope. As the ice melts, islands are being uncovered and people have bagged some of these as new discoveries. In 2004, a British artist called Alex Hartley claimed to have found a recently exposed island in the Svalbard archipelago. The piece of land, which Hartley dubbed Nymark ("new land" in Norwegian) is about the size of a football field. In 2005, Schmitt claimed to have discovered a similar island off the east coast of Greenland, which he named Uunartoq Qeqertoq ("warming island" in Inuit). At the present rate of melting there will be plenty more where that one came from. Richard Fisher

Bouvet Island, the most desolate and isolated piece of land on earth



It may be little more than a bank of loose gravel, but Oodaaq is on the map

GALER ROWELL/GETTY

...where no explorer has set foot

YOU could be forgiven for thinking that there are few places on Earth yet to be conquered by humans, but you'd be wrong. Countless areas, from polar islands to tracts of remote desert, remain virgin territory.

For most of these places there is a good reason why nobody has ever set foot there: nobody wants to. What counts in the world of exploration is conquering places that others wish they had been to first. Even so, there are desirable destinations that remain unvisited by even the hardest explorer.

One good place to look is in the world of mountaineering, where numerous high peaks remain unclimbed. Top of the list is Gangkhar Puensum in the kingdom of Bhutan. Standing at 7541 metres, it is the 40th-highest mountain in the world and the highest unclimbed one. Mountaineers have tried to reach the summit on three occasions, and failed each time. It is likely to remain out of reach for the foreseeable future, as in 1994 Bhutan banned the climbing of peaks higher than 6000 metres out of respect for local spiritual beliefs.

This, however, still leaves thousands of virgin peaks. "I am amazed that each year climbers still find new ones," says Bill Ruthven of the Mount Everest

Foundation, a UK charity that supports mountain exploration. The hotspots are Greenland, Antarctica and the Nyainqêntanglha East region of Tibet, where 159 out of 164 peaks above 6000 metres have still to be climbed.

Another of the Earth's great unexplored domains is underground. New caves and passages are being discovered all the time, even in densely populated countries. The UK's largest shaft, Titan in Derbyshire, for example, was not discovered until 1999. "Not a week goes by without something new being found," says Chris Howes, editor of the caving magazine *Descent*.

Caves offer the best chance for an ordinary person to discover a new place. "Virgin caves count as perhaps the only places on Earth that are not only unexplored but unknown," says Bill Mixon of the Association for Mexican Cave Studies. "They can't be photographed or mapped from the air or space." However, caving can sometimes be even more challenging than mountaineering.

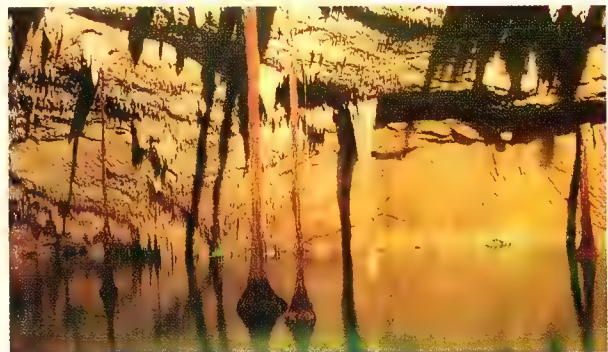
Take Voronya cave in Abkhazia, Georgia, the world's deepest cave at 2170 metres. An expedition in January 2007 uncovered an extra 30 metres of passage – no mean feat when you consider that much of

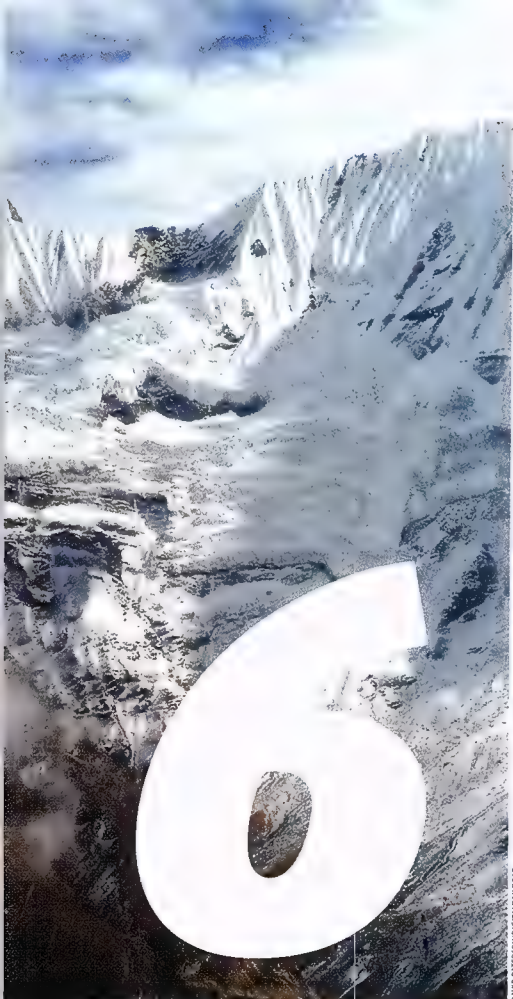
the cave is underwater. Another Mecca for cave exploration is the vast network of caves in Yucatán, Mexico. Some 500 kilometres of passageways have already been explored, but there are countless more still to be discovered – many of them also underwater.

Then there's the ocean. In August, an expedition run by the P.P. Shirshov Institute of Oceanology in Moscow plans a unique visit to the North Pole – approaching it from below the Arctic ice. What do they expect to find there? "Quite honestly, mud," says Mike McDowell of Deep Ocean Expeditions, who is helping to organise the venture.

This should be a reminder to those hankering to conquer virgin territory: the most extreme places are often the most desolate too. Alison George

Huge water-filled cave systems in Mexico still offer a chance for glory





Machapuchare, one of dozens of unclimbed peaks in the Himalayas

DAVID PATRICKSON/GETTY IMAGES

7...where you can still hear the strangest languages ever spoken

THE death of any language is a tragedy, but some are a more distressing loss than others. A handful of endangered languages are the last refuges of odd linguistic features that, once their host language disappears, will be gone forever.

One is Tofa, spoken by a handful of nomads in the Eastern Sayan mountains of southern Siberia. Starting in the 1950s, the Soviet government forced the Tofa people to learn Russian and abandon their traditional ways of life. Now, there are only 25 Tofa speakers left, all elderly. When they die, one utterly unique feature of Tofa will disappear: a suffix, *-sig*, that means "to smell like." In Tofa you can add *-sig* to the word *ivi-*, (reindeer) to describe someone who smells like a reindeer. No other language in the world is known to have this kind of suffix.

Linguist K. David Harrison of Swarthmore College in Pennsylvania has documented similar examples of endangered "information packaging" systems in his book *When Languages Die*. One of these is the body counting system used in an estimated 40 languages in Papua New Guinea. In languages like Kaluli and Kobon, the words for numbers are the names of body parts. So 1 to 10 in Kobon are "little finger, ring finger, middle finger, forefinger, thumb, wrist, forearm, inside elbow, bicep, shoulder." To count higher, you count the collarbone and the hollow at the base of the throat – and then right down the other side, all the way to 23. You can count to 46 by counting back the other way and even higher by starting over and doing it all again. So 61 in Kobon is "hand turn around second time go back biceps other side". Michael Erard

...without living things

WHEREVER biologists look for life on Earth, they tend to find it – with two notable exceptions. One is the large expanses of bare ice and snow found in Antarctica and Greenland, which comes as little surprise. The other is more of a mystery: an area called Yungay in the heart of the Atacama desert in northern Chile, the only tract of dry land that seems to have no surface life at all.

Although it is one of the driest regions of the world's driest desert, Yungay's lifelessness is baffling. This unique condition makes it unlike any other desert on Earth, according to teams of NASA researchers who have been doing fieldwork there for more than a decade. That's what keeps them coming back. They are eager to uncover the secrets of the absolute limits that terrestrial life can endure, as it could provide clues to the necessary conditions for life on other worlds.

"It's not clear what is limiting life there," says Chris McKay, a planetary scientist at NASA's Ames Research Center in California. "It could be the availability of food, or water. Both are in short supply. In other places [in the Atacama] that

are rich in life, both are brought in by fog." But the fog doesn't reach Yungay.

Part of the problem is that where microbes do take hold, there are so few of them that they are at the very limits of detectability. The first few years of sampling and testing suggested that the entire Yungay area was sterile. Then last year signs of life turned up. Jacek Wierzbos of the University of Lleida in Spain found a hardy variety of cyanobacteria inhabiting cracks in salt crystals, harnessing salt's ability to draw water from the air – an adaptation that had never been seen before. Richard Quinn, a NASA biologist, also found traces of microbial life in some parts of the arid soil next to apparently identical areas that are lifeless.

Tests on the soil samples continue, but so far the secret to lifelessness remains a mystery. Solving it may be a key to eventually figuring out whether the ruddy soil of Mars is as lifeless as Yungay, or filled with hardy microbes like the soil under our feet. David L. Chandler



KARSTEN HANKE/BLUBERG/AMERICA PRESS

...where dinosaurs walked

EVEN though it happened 65 million years ago, we are pretty sure we know what happened to the last of the dinosaurs: they died when a 10-kilometre-wide asteroid struck what is now the Yucatán coast of Mexico.

Pretty sure, but not completely. A few palaeontologists insist that a few “Lazarus” species limped on after the impact, surviving for another million years or so.

Keith Rigby of the University of Notre Dame in Indiana is one. He has collected a large number of dinosaur teeth from Montana in sediments that formed about half a million years after the impact. The big question is whether the teeth came directly from living animals, or were “reworked” from older sediments. Rigby is convinced it is the former. “We’ve got some that are pristine,” he says, with edges as sharp as the day the dinosaur shed them. Others are sceptical. “There’s no proof that they are not reworked,” says David Archibald of San Diego State University in California.

Rigby has also reported dinosaur fossils, including intact nests with eggs and footprints, from post-impact sediments in the Nanxiong basin in China. Even his critics agree that

some of the fossils are in post-impact sediments, but argue that these too are reworked. They point out that all the footprints and intact nests are below the impact layer; above it are only fragments of eggshell and bone.

Jim Fassett of the US Geological Survey, meanwhile, has reported finding a pristine dinosaur femur in rocks containing post-impact pollen in the San Juan basin of New Mexico. However, others have failed to confirm his pollen finding and so are not convinced that Fassett is right.

In the absence of unequivocal evidence of Lazarus dinosaurs, the last clear evidence of living dinosaurs is a series of tracks made by a family of duck-billed plant eaters in what is now Ludlow, Colorado. The footprints were found in a slab just below the layer marking the impact. “The dinosaurs were alive and well, walking about at the very last minute,” says Martin Lockley of Colorado University at Denver. But his timescale is geological: there are probably at least 1000 years between the footprint layer and the impact itself. Even so, Colorado is the last place we can say for sure that dinosaurs walked. Jeff Hecht

Did dinosaurs live on in the badlands of New Mexico?

...to have permanent ice cover

EARTH'S ice is dwindling, and fast. If this keeps up, where will the permanent ice last longest?

Certainly not in the Arctic. In the past 20 years the Arctic Ocean has lost about 10 per cent of its permanent ice cover, and the rate is accelerating. "Multi-year ice could be gone in 40 to 50 years," says Ron Kwok of NASA's Jet Propulsion Laboratory in Pasadena, California.

With the north defrosted, ice will make its last stand in Antarctica. The coldest continent on Earth is expected to stay that way for the foreseeable future, but changes in ocean circulation are speeding up ice losses in the western half of the continent. This is especially true in areas such as the Amundsen Sea Embayment, where warm waters are welling up

underneath a vast ice shelf, causing it to melt and drag glaciers on land seaward. Still, mile-thick ice remains over much of this Texas-sized region.

East Antarctica is a different story. Its ice cover has been stable in recent years, and has even grown a bit. This is because it has very few shelves extending into the ocean, preventing exposure to the warm waters swirling offshore. With air temperatures holding steady for the time being, the ice sheet is likely to remain healthy for some time, though no one can predict exactly how long.

Chances are that by the time East Antarctica is the last place on Earth covered in ice year-round, we won't know about it. Civilisation will probably have collapsed as a result of a 70-metre rise in sea level. Michael Reilly

11 ...to make radio contact with the rest of the world

ON 28 July 2006, amateur radio enthusiasts received the news they had been waiting for. Swains Island, a minuscule atoll in the Pacific Ocean more than 300 kilometres north of Samoa, was officially on the air. It thus became the 337th and last place on Earth to make radio contact with the rest of the world.

Swains Island, population 37, was on air for only six days, but in that time it made a lot of people very happy. For many radio hams there is nothing better than to collect a "QSL card" – confirmation of two-way radio contact – from an obscure location on the other side of the world. Swains Island was (and still is) one of the most sought-after locations.

In amateur radio parlance, these locations are called entities. There are 337 in total, on a list administered by the American Radio Relay League (ARRL) based in Newington, Connecticut. Entities range from nation states recognised by the UN to tiny specks of land that barely register a dot on the map. Radio hams strive to collect QSL cards from as many

entities as possible, and anyone who collects 100 or more is eligible for the prestigious DX Century Certificate.

To qualify as an entity, a location has to fulfil a simple condition: it either has to be a discrete political entity or a discrete geographical entity. France, for example, qualifies, but so do its overseas territories such as Guadeloupe. Swains Island is on the list because although it is administered by American Samoa – itself a US territory, administered from Washington DC – it is far enough from the main group of islands to count as a discrete geographical entity.

What took radio hams so long to conquer Swains Island? Actually, nothing. The ARRL only declared the island a separate entity on 24 July 2006. Four days later it was on the air, thanks to a team of Japanese, French and American hams who were poised in Hawaii awaiting confirmation that Swains Island was on the list. This is a familiar tale with new entities. When Ducie Island, an uninhabited atoll 540 kilometres east of

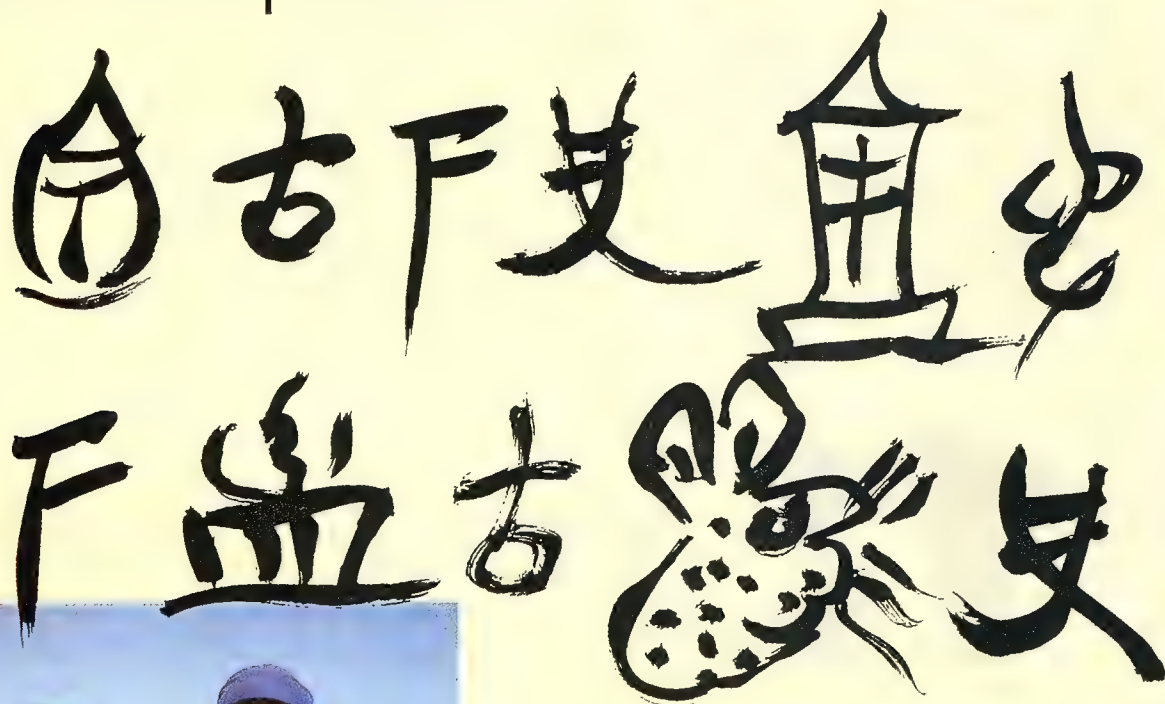
Pitcairn Island, became the 335th entity on 16 November 2001, a team of hams set sail the next day. Then appalling weather forced them back, but they eventually made it and started transmitting in March 2002.

This irrepressible desire to send and receive radio signals from far-flung places means that radio hams have visited some of the most remote and inhospitable places on Earth, including Bouvet Island (see page 34) and Scarborough Reef, a guano-covered shoal in the South China Sea. Besides having barely enough dry land to support a radio transmitter, ownership of the reef is contested by China, Taiwan and the Philippines. An amateur radio expedition there in 1997 almost sparked an international diplomatic incident.

The ARRL updates its list of entities every year, so at some point Swains Island will be joined by a 338th. No doubt it will then quickly cede its title as the last place on Earth to make radio contact with the rest of the world. Graham Lawton

...where people
write with pictures

12



Dongba, the only
living pictorial script
in the world



SOME 8500 years ago, people in what is now China started using written symbols to communicate and store knowledge. At first they used pictures to represent words and ideas – a characteristic shared by other early scripts such as cuneiform and hieroglyphs. These pictographic scripts have since fallen into disuse, superseded by more abstract writing systems such as the one you are reading now. All except one, that is.

In the mountains of south-west China, a dwindling number of priests practising an animist religion still read and write with pictures. Theirs is the last living pictographic script anywhere in the world.

The writing system is called Dongba and it has been used for about 1000 years to record and guide the religious traditions of the Naxi, a 300,000-strong people living in Yunnan, Sichuan and Tibet. The Dongba script has more than 2000 pictographs, including dagger-wielding demons,

giant birds and ferocious tigers. These take on different meanings depending on where they are in relation to others, but are hugely literal. To write the word “snatch”, for example, Dongba uses a bird falling prey to an eagle’s claw. For “absorb”, it depicts a man sucking from a bowl. The script is too complex for everyday use; it is used in religious ceremonies, as a prompt for storytelling.

In Naxi society only shamans learn to read and write the script. Historically, the skill was passed down from priests to their sons. During China’s Cultural Revolution, Dongba was suppressed and thousands of ancient manuscripts destroyed. Today fewer than 60 scholar-priests remain, the vast majority of them aged over 60, says Yang Fuquan of the Yunnan Academy of Social Sciences in Kunming, China.

Efforts are under way to keep the Dongba script alive. Since 1981, when Yunnan’s provincial government formed the Dongba Culture Research Institute in Lijiang, elders have translated more than 1000 texts into modern Chinese. The institute has also started formal apprenticeships lasting six to seven years to teach the script and religious practices. Yang, himself a member of the Naxi, estimates that as many as 200 young Naxi are studying to become Dongba priests.

Even so, Yang remains concerned that the language and culture are being lost amid China’s rapid modernisation. “It’s very easy to encourage students to write some basic characters,” he says. “The difficult thing is to preserve a living culture with master Dongbas in the communities.” Phil McKenna

...to rise from the waves

THE sea bubbled and boiled, steam rose and rocks spat forth into the air. Slowly a mound began to emerge from the waves, and within days a new island was born. It might sound like something from the book of *Genesis*, but it is just how the world's newest island emerged from the ocean.

On 9 August 2006, yachts sailing around Tonga reported sightings of a submarine volcanic eruption at Home Reef, south of Late Island. Three days later the crew of the Norwegian yacht *Maiken* caught sight of an island not found on any nautical chart. Approximately 1.5 kilometres across, it was capped by a huge plume of steam, and the sea for miles around was covered with floating rafts of pumice spewed out by the eruption.

By mid-October, eruptions on the island had ceased and its demise began. This is often the way with new islands: if the rock doesn't have time to consolidate, waves quickly wear it away. By 8 December, when a New Zealand military plane took the last published photograph, Home Reef island had shrunk by more than half. "There's probably not that much left of it now

except a bit of discoloured water," says David Pyle, a volcanologist at the University of Oxford.

Home Reef isn't the first submarine volcano to break the surface: Surtsey famously did so off the south coast of Iceland in 1963, this time with enough oomph to become a permanent feature. It won't be the last, either. Hiding less than 10 metres below the surface of the Mediterranean, 40 kilometres off the south coast of Sicily, is the spout of the submarine volcano Empedocles. The last time it erupted, in July 1831, it produced an island 4 square kilometres in area. The Italians (who named it Ferdinandea), French (*Île Julia*), British (Graham Island) and Spanish all laid territorial claims to the new island. But by January 1832, before they could settle their dispute, the island was washed away.

Empedocles rumbled again in 2002, raising the possibility of another territorial dispute. So far there's been no sign of it breaking the surface, but just in case Ferdinandea does re-emerge Italian divers have planted a flag on the volcano's submerged summit. David Cohen

...to be unclaimed by any nation

SADLY there is not really any such place. Every single piece of claimable land on Earth has been bagged by someone. There's a strong incentive for doing so, as owning even a remote rock can significantly extend a nation's access to marine resources such as oil and fish.

States will go to great lengths to secure territorial claims over what appear to be worthless pieces of land. Tiny, uninhabited Hans Island, which sits between Greenland and Ellesmere Island, is claimed by both Canada and Denmark. They opened talks in 2005 but have yet to settle the water and island yet and up in the court of law (courtesy of *the Economist*).

to give up without a fight, as the case may set a precedent for other territorial disputes in the Arctic Ocean.

Despite this, there is land that has not fallen to national claims because it is considered unclaimable. All territorial claims on Antarctica were frozen in 1961, when the Antarctic treaty came into force. Argentina, Australia, Chile, France, New Zealand, Norway and the UK had by then made unrecognised claims, but 1.6 million square kilometres of West Antarctica known as Marie Byrd Land, roughly one-tenth of the whole continent, had not been claimed by any country. It remains the only unclaimed land on Earth. Graham Taylor

ARND BRONKHORST/ARND BRONKHORST NATIONAL SPACE CENTRE

14

Tiny, icebound and uninhabitable, Hans Island is desirable all the same

...anyone would want to live

Are you happy where you live? It's a tricky enough question to answer on an individual, subjective level, and harder still when it comes to arriving at an objective judgement. There are so many factors to take into account. Is access to healthcare more important than pollution levels? Should low crime rates be counted a higher priority than freedom of speech?

Economists sometimes use a country's per capita gross domestic product – the value of all the goods and services it produces – as an indicator of quality of life, but it is only a crude one. To give a more rounded picture, the UN produces an annual "human development index", which assigns a score to each nation based on three broad sets of indicators: health and longevity, knowledge and education, and standard of living measured by purchasing power.

By these measures the worst place to live is Niger in west Africa, where life expectancy is 44.6 years, 71 per cent of adults are illiterate and 79 per cent of children don't go to school. In the top nation, Norway, people are 40 times wealthier, live almost twice as long and enjoy near universal education.

The UN's method has two big flaws, though. First, some nations where life is undoubtedly tough are unwilling or unable to provide the necessary data, notably Iraq, Afghanistan, Liberia, Somalia and North

Korea. Equally importantly, there's more to well-being than a long, prosperous life. Norway may be top of the UN chart, but it surely can't be that much fun living in a country where winter can bring a mean monthly temperature of -15 °C, the sun does not rise for two months of the year, and you'll need a second mortgage to buy a drink in a bar.

Ruut Veenhoven, a sociologist at Erasmus University in Rotterdam, the Netherlands, says that while the UN's indicators clearly give some idea of quality of life, ultimately the only way to find out how happy people are is to ask. He has created a ranking of global happiness based on the results of surveys in 90 nations, which reveals that the country where people are least happy to live is Tanzania (perhaps reflecting the fact that the country was ravaged by drought at the time of the survey) closely followed by Zimbabwe.

Much of Africa and the Middle East does not figure in Veenhoven's survey, but later this year, market research firm Gallup will release a survey with a slightly wider reach, covering around 120 countries. It should at least bring us a little closer to a definitive assessment of the last place on Earth anyone would want to live. Richard Fisher

**Niger in west Africa is
officially rated the
worst place to live**



16



Even Stalinist
backwaters can fall in
love with Coca-Cola

...where no one has tasted Coca-Cola

No trade sanction or hostile regime seems able to stand in the way of this quintessential symbol of American capitalism. The Coca-Cola Company says its fabled drink is on sale in more than 200 countries worldwide – that's more than are members of the UN. You can buy it in locations as remote as Antarctic research bases, and it has even crept into countries where US companies are barred from doing business.

Cuba, for instance, imports Coca-Cola from Mexico, and a good thing too, as Coke is a key ingredient in the national drink, Cuba Libre.

Even inclusion in George W. Bush's "axis of evil" hasn't stopped nations enjoying the stuff. In Iran, local bottling factories manufacture and distribute Coke. North Korea opened its doors to imports in 1999. Coca-Cola is quick to point out that it does not operate there, but there is nothing to stop a third party shipping the drink across the border.

Chinese-branded Coke is reportedly on sale in Pyongyang. You can buy it in most hotels and restaurants frequented by westerners, plus a handful of street stalls. The locals seem to have developed a taste for cola, and the government has recently developed a domestic rival. "It is unbelievably revolting, like syrup," says Simon Cockerell, who organises tours to the hermit state. All of which goes to show there really is nothing like the real thing. Richard Fisher

17

...to survive when the sun explodes

What is the last place on Earth? The very last place on Earth, ever? Here's a clue: wherever on the surface of the planet you are now sitting, it's around 6400 kilometres and 5 billion years away.

That date, more or less, is when the sun becomes a red giant. It will do so twice. First it will swell to about the size of Earth's orbit today. We are likely to escape being swallowed at that point, because the sun will have shed some of its mass, weakening its gravitational grip, so we will be orbiting somewhat farther out than today. Then after a few hundred million years, during which the sun will have briefly shrunk to a more sensible size, it will become a giant again, this time growing larger still.

Its outer envelope of hot gas probably won't quite reach the Earth at first, but we are likely to be dragged in eventually. "If the Earth is not engulfed the first time, it will almost certainly be engulfed the second," says astrophysicist Arnold Boothroyd of the

University of Toronto in Canada. The sun might even play cat and mouse with us, flaring up from time to time to toast Earth in 3000 °C plasma, then contracting, only to finally swallow us millennia later.

That is only the beginning of the end. The outer layers of a red giant are remarkably tenuous, so Earth will plough on, continuing to orbit the sun's core for thousands of years. The crust will melt into an ocean of magma, but for a while not much of the planet will evaporate.

As Earth gradually slows down and spirals inwards, the temperature will climb. Eventually, when we are a few million kilometres from the core, it will reach a critical level of about half a million degrees, according to astrophysicist Noam Soker of the Israel Institute of Technology in Haifa. At that temperature, the oxygen and silicon atoms boiling out of the magma ocean will be travelling fast enough to escape Earth's gravity, and the evaporation will suddenly

accelerate. Soker estimates that it will only take a year for the whole planet to go. "The hot solar envelope will peel the Earth layer by layer," he says.

There is in fact a chance that the red giant will never grow quite large enough to swallow Earth. If it escapes this fiery end, our dry and lifeless planet will continue orbiting for aeons as the sun settles down to become a white dwarf. Eventually, Earth should spiral in and hit the sun's cinder – though there is an outside chance that it could endure until the end of the universe, squashed into the final singularity of a big crunch, or torn apart in a big rip.

Overall, though, the odds are that the end will come as our sometime home is swallowed up by the sun. Then the last place on Earth – the very last fragment to go – will be a piece of iron from near the centre of today's inner core: a white-hot droplet of liquid metal rapidly boiling away to nothing. Stephen Battersby ●

Back to their roots

Snakes lost their legs, we lost body hair, but that's minor compared with some species. We have vastly underestimated evolution's fondness for pruning, says **Laura Spinney**

IF YOU want to know how all living things are related, don't bother looking in any textbook that's more than a few years old. Chances are that the tree of life you find there will be wrong. Since they began delving into DNA, biologists have been finding that organisms with features that look alike are often not as closely related as they had thought. These are turbulent times in the world of phylogeny, yet there has been one rule that evolutionary biologists felt they could cling to: the amount of complexity in the living world has always been on the increase. Now even that is in doubt.

While nobody disagrees that there has been a general trend towards complexity – humans are indisputably more complicated than amoebas – recent findings suggest that some of our very early ancestors were far more sophisticated than we have given them credit for. If so, then much of that precocious complexity has been lost by subsequent generations as they evolved into new species. “The whole concept of a gradualist tree, with one thing branching off after another and the last to branch off, the vertebrates, being the most complex, is wrong,” says Detlev Arendt, an evolutionary and developmental biologist at the European Molecular Biology Laboratory in Heidelberg, Germany.

The idea of loss in evolution is not new. We know that snakes lost their legs, as did whales, and that our own ancestors lost body hair. However, the latest evidence suggests that the extent of loss might have been seriously underestimated. Some evolutionary biologists now suggest that loss – at every level, from genes and types of cells to whole anatomical features and life stages – is the key to understanding evolution and the relatedness of living things. Proponents of this idea argue that classical phylogeny has been built on rotten foundations, and tinkering with it will not put it right. Instead, they say, we need to rethink the process of evolution itself.

It is not hard to see how the mistake might have happened. In the past, the tree of life was constructed on the basis of similarity of morphological features. The more similar two

species looked, the more closely related they were thought to be. But looks can be deceptive. This became abundantly clear more than a decade ago, when molecular biologists began comparing small numbers of genes from various organisms and found that many species were not what they appeared. Hippos, for example, were once thought to be the kissing cousins of pigs, but genetic evidence revealed their closest living relatives to be the cetaceans (whales, dolphins and porpoises).

Without the insights of molecular analysis, traditional morphologists also had no way of knowing whether a particular feature had been lost in a given lineage, or had never been



there in the first place. In line with the idea that things evolve towards increasing complexity, they tended to assume the latter, sometimes quite incorrectly. Take the sea squirt. Its larva swims around looking like a tadpole, with a nerve cord along its back, gill slits for feeding and a tail – all classic features of chordates, the large group of animals with backbones that includes us. Then, however, it stands on its head and turns into a sack of jelly, having first digested what it had of a brain. The adult looks suspiciously like a plant. For a long time it was considered to be one of the most primitive chordates because of its simple adult form – about as far from vertebrates as it was possible to get. In between were myriad other groups, including the lancelets – fish-like animals that hang on to their nerve cords into adulthood. Then molecular studies revealed that sea squirts are genetically closer to us than are lancelets, and the tree had to be reshuffled.

In recent years, genetic analysis has forced biologists to consider the possibility that organisms such as the sea squirt might have lost some of the complexity of their ancestors. Yet even now, few recognise the full implications of loss as a key player in evolution. The entire tree of life has been built

on the assumption that evolution entails increasing complexity. So, for example, if two groups of animals were considered close because both had a particular prominent feature, then someone discovered a third, intermediate line that lacked that feature but shared many other aspects of the two groups, traditional phylogenists would conclude that the feature had arisen independently in the two outlying groups, by a process known as

“The more similar two species looked, the more closely related they were thought to be. But looks can be deceptive”

convergent evolution. They often did not even consider the alternative explanation: that the feature in question had evolved just once in an ancestor of all three groups, and had subsequently been lost in the intermediate one. Now a handful of molecular biologists are considering that possibility.

Instead of simply looking to see whether two species share certain genes, the new approach involves taking the “molecular fingerprint” of different types of cells. It

identifies the unique combination of transcription factors – molecules that control which of a cell’s genes are turned on and when – that specify the make-up of a cell, including the molecular signals it transmits and receives. If two groups of organisms share the same type of cells, with the same molecular fingerprint, giving rise to similar features in both, then it is extremely unlikely that these features evolved twice. So any

intermediate groups of organisms that lack that feature would most likely have lost it during the course of evolution. Only now, with the ability to explore at the molecular level how morphological features have been lost, gained and modified over time, is the true extent of evolutionary loss coming to light.

Arendt’s convictions about the vast scale of this loss are based on his molecular fingerprinting studies of a tiny annelid worm called *Platynereis dumerilii*. It is an



unprepossessing animal that lives in tubes stuck to rocks in shallow seas, bathed in a nutritious blanket of algae and reproducing according to the tides and the lunar cycle. "We think that it has always lived in this ecological niche," he says, "and that this might resemble the environment of the common ancestor [of all animals that are symmetrical along the axis from head to tail]". This enormous group, called bilaterians, encompasses all vertebrates and most invertebrates; the descendants of a long-extinct creature known as *Urbilateria* that lived between half a billion and a billion years ago. No fossils of this species have been found, but as *Platynereis* is thought to have occupied the same niche as *Urbilateria*, Arendt suspects it might also have retained some of the mysterious ancestor's features.

Brainy ancestors

What Arendt's group has discovered about the brain of this lowly worm is intriguing. Within the animal kingdom, the simplest and most evolutionarily ancient type of nervous system is a diffuse neural net. Sea anemones and corals, for example, have this system, in which a single type of neuron is distributed throughout the animal. More recently evolved species have a central nervous system (CNS), with specialised sensory and motor neurons clumped together into a nerve cord and brain.

A CNS is found in all vertebrates and some invertebrates, including *Platynereis* and two of biology's supermodels, the fruit fly *Drosophila melanogaster* and the nematode worm *Caenorhabditis elegans*, but there are obvious differences between the vertebrate and invertebrate CNS. Vertebrates have a spinal cord at the back, while invertebrates usually have a chain of neuronal clusters or ganglia, connected like a rope ladder, in their belly. This led morphologists to think that *Urbilateria* had a diffuse neural net and that centralisation arose separately by convergent evolution in the different lines after they split. Arendt believes they were wrong.

Earlier this year, his group reported that *Platynereis* neurons share molecular fingerprints with vertebrate neurons during development (*Cell*, vol 129, p 277). For example, genes known to be important in patterning the vertebrate CNS also divide the worm's nervous system into domains. What's more, domains with corresponding gene expression patterns give rise to the same types of neurons in both. Arendt concludes that *Platynereis* and vertebrates both inherited their CNS from *Urbilateria*. The reason they take a different

form today, he suggests, is that when early vertebrates began swimming freely, "front" and "back" lost their significance and the animals simply inverted the two. As the rope ladder nervous system became enclosed in the neural tube characteristic of vertebrates, the ancestral mouth was trapped inside. It is still detectable there, Arendt says. Using the molecular fingerprinting technique he has been able to find this obsolete mouth within the vertebrate brain. "Its position is very clear," he says, "It's behind the hypothalamus."

If Arendt is correct, then the ancestral CNS was lost completely in two major animal groups: the echinoderms (starfish, sea urchins and the like) and hemichordates (acorn worms and other worm-like marine organisms). Both of these are sister phyla to chordates (see Diagram, below), yet their members have lost their brains and instead have diffuse neural nets. The same seems to be true of various molluscs, brachiopods, phoronids and bryozoans that have evolved to be sedentary filter-feeders. "If you just sit around your entire life you don't need much of a sensory integration centre coupled to a locomotor nerve cord," says Arendt.

Not everyone agrees, however. In 2003, Chris Lowe from the University of Chicago and colleagues compared the genes expressed in the development of the acorn worm and

vertebrate nervous systems. "We showed that the exact same genes are involved in patterning a nerve net as in patterning a CNS," he says. "So our argument is that you cannot use these genes as really solid markers of a CNS." Given the scarcity of comparative molecular data so far, Lowe thinks it is too early to rule out convergent evolution in annelids and vertebrates.

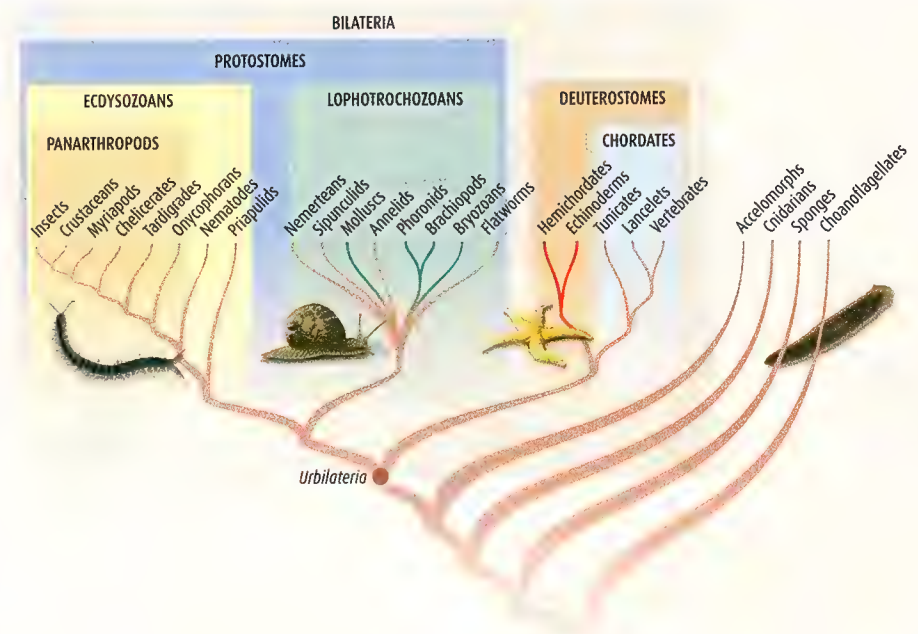
While controversy continues to rage over convergent evolution versus loss, it has emerged that *Urbilateria* is not the only very early animal ancestor that was more complex than some of its descendants. David Miller of James Cook University in Queensland, Australia, studies the coral genus *Acropora*, the main reef-building corals of the Indo-Pacific region. *Acropora* belongs to the phylum of cnidarians, which are thought to have branched off after *Urbilateria*, the common ancestor of all animals, but before *Urbilateria*. Yet Miller is uncovering surprising genetic complexity in *Acropora*.

For example, it has a version of a gene that was thought to be exclusive to vertebrates as it is involved in the vertebrate immune system, which works by remembering past threats and adapting its response to them. "All the textbooks tell you that adaptive immunity is a specific characteristic of vertebrates," Miller says, "yet at least one of

SOME OF OUR BRAINS ARE MISSING

The discovery that *Urbilateria*, the ancestor of all bilaterians, probably had a brain implies that some of its descendants must have lost theirs

— All species have lost their brains — Some species have lost their brains





Max Telford from University College London gives the example of a genus of barnacle called *Sacculina*. Barnacles are crustaceans that don't look much like crustaceans because they are filter-feeders and sessile, meaning they anchor themselves to a substrate – often boats or piers. *Sacculina* doesn't look like a barnacle, let alone a crustacean. It parasitises crabs, producing an almost plant-like system of roots which invades the host tissue. It is known to be a barnacle only because it has a barnacle-like larval stage. "So barnacles have lost many crustacean characters because they are sessile, and *Sacculina* has gone even further because it is parasitic," says Telford.

Another driver of simplification might be miniaturisation. Rotifers are microscopic aquatic organisms with a feeding wheel – tufts of cilia around the mouth that waft food into it – and nothing that could strictly be called a brain. Arendt believes that they represent the larval stage of an animal that, on shrinking to fit its planktonic niche, discarded its adult body plan and developed no further, becoming sexually mature early. "This is one very efficient means of throwing out ancestral complexity and becoming secondarily simple, and I think it happens frequently," he says.

If loss is so common, the challenge now is to distinguish the organisms that were always simple from those that have evolved simplicity. Genetics will be an invaluable tool here, but it will take a lot more analysis and comparison between a wide range of species before a definitive tree of life emerges. The very genetic complexity of *Acropora*, for example, has led some to question its position in the tree, arguing that it may have evolved later than was thought – that it may in fact be a descendant of *Urbilateria* that became secondarily simple while retaining genes that were later incorporated into the vertebrate immune system. If evolutionary biologists today are to avoid the mistakes of their predecessors, they need to eliminate precisely that kind of circularity.

"Molecular biology is making real inroads into this, but it has not been easy to reconstruct events that happened over half a billion years ago," Martindale says. Still, the new phylogenists are more resolute than ever. "There can only be one true relationship of animals to one another," he says. ●

Laura Spinney is a writer based in London and Paris

"Now that the spectre of loss has been raised, proponents of the new model see it everywhere"

the proteins is clearly present in our animal."

Miller's findings are intriguing, but more work is needed to pin down the origins of adaptive immunity. The dangers of jumping to conclusions about early evolution followed by loss on the basis of limited genetic information are highlighted by work on body segmentation. Many bilaterians have bodies made up of repeating anatomical units, and the discovery of certain similarities between the developmental genes that determine segmentation in *Platynereis* and in insects suggested a common origin. Then Elaine Seaver at the University of Hawaii's Kewalo Marine Lab in Honolulu used molecular fingerprinting to show that almost none of the genes involved in insect or vertebrate segmentation are deployed in the same place at the same time in developing annelids. "The evidence is accumulating that segmentation arose at least three times independently," says Seaver's colleague Mark Martindale.

Now that the spectre of loss has been

raised, however, proponents of the new model see it everywhere – everywhere, at least, where animals have evolved to occupy niches in which their pre-existing complexity might be superfluous. Last month, Marcus Davis of the University of Chicago and colleagues reported that a species of paddlefish shows patterns of gene expression during development that were previously thought to be exclusive to land-living vertebrates – in other words, those with limbs. This paddlefish is the living species that most closely resembles the bony fish of the Palaeozoic era, which lived more than 250 million years ago. Davis concludes that primitive bony fish may have had something like limbs, which were lost in their descendants (*Nature*, vol 447, p 473).

Parasitism is another potential driver of simplification. When one living organism colonises another, it may discard features it could not have survived without as a free-living creature – features that gave it mobility and the ability to seek out food, for instance.

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A bodyguard for the truth

Jeff Ruch was fresh out of law school when he learned what can happen if you cross a powerful politician. After writing a report that angered one of his bosses at the California state legislature, Ruch was sacked. Two decades later he created his own organisation to protect government whistle-blowers, many of them scientists. Ruch told **Jim Giles** about holding George W. Bush's administration to account, and why a new president may not make scientists safer

What happened in California?

I was writing a report on a proposed prison. It was on a contaminated site and they weren't going to do an environmental review. I put this in my report, and the speaker of the Californian assembly changed it. The *Los Angeles Times* picked up on it and the speaker was embarrassed. I was called into his office and told to vacate the premises by the end of the day. They thought I had called the *Times*. I hadn't, but I had told someone who then did.

So you were out of a job?

I was fired and blackballed. The speaker said he'd look darkly on me being employed by anyone within his realm of influence – my entire professional world. Luckily the chair of the assembly's labour committee rescued me by withholding contributions to the speaker from labour unions. The incident taught me how fragile government careers are. They can be snuffed out if you offend the powerful.

How did you come to set up your own group?

In 1991 I went to work for the Government Accountability Project in Washington DC. We gave help and legal advice to public and private sector employees victimised for whistle-blowing. It was like a legal emergency room. We got calls from all over saying, "They're about to fire me." I realised we needed to take preventive action and help people to disclose problems, perhaps without going public themselves. So I and some others set up Public Employees for Environmental Responsibility [PEER] in 1993.

What is the philosophy at PEER?

Deliver the message without the messenger. We sell [PEER-branded] boxer shorts, but not

T-shirts – you can wear boxers to work and no one knows. The important thing is to ventilate the bureaucracy. If anything that happens can end up on the front page the next day without management knowing how it got there, that changes how government agencies operate.

Who are you most proud to have helped?

One was Don Sweeney, an economist with the Army Corps of Engineers. It was 2000, and there was a multibillion-dollar plan to expand dams on the Mississippi river. Sweeney oversaw the cost-benefit survey for two years, but when it became clear that the project wasn't going to be cost-effective, he was told to change the numbers.

And did he?

No. He was told to think about his family – it was very heavy-handed – but he wouldn't change the figures so he was removed from the assignment. Then he called us. We advised him to go public, since he had already been sidelined. He had explicit emails from top commanders saying they didn't want "limp-wristed numbers". We helped him get the story into the media and it hit like an atom bomb. It started an investigation that ultimately vindicated him. Sweeney served

out his career as a university professor. His information produced change and he emerged professionally unscarred.

Presumably some whistle-blowers would rather not be identified?

Yes. Early in the first Bush administration there was debate about whether to drill for oil in the Arctic National Wildlife Refuge in Alaska. The Department of the Interior promised not to alter the science on the potential impacts of the drilling on wildlife. But the Fish and Wildlife Service, part of the DOI, delivered a fairly negative assessment. This went to the secretary's office at the DOI and came out with 17 major changes: things like "is" changed to "is not", numbers changed. All the changes minimised the effect of the drilling. The people with the paper trail showing these changes were terrified.

How do you reassure people like that?

We always say that they're the brain and we're the stationery. They have final sign-off on everything we do. In the end, we gave that story to *The Washington Post*. The drilling has been blocked ever since. I don't know if the whistle-blower has retired yet, but there hasn't been any reported blowback.

Were you concerned that the DOI could have identified the source?

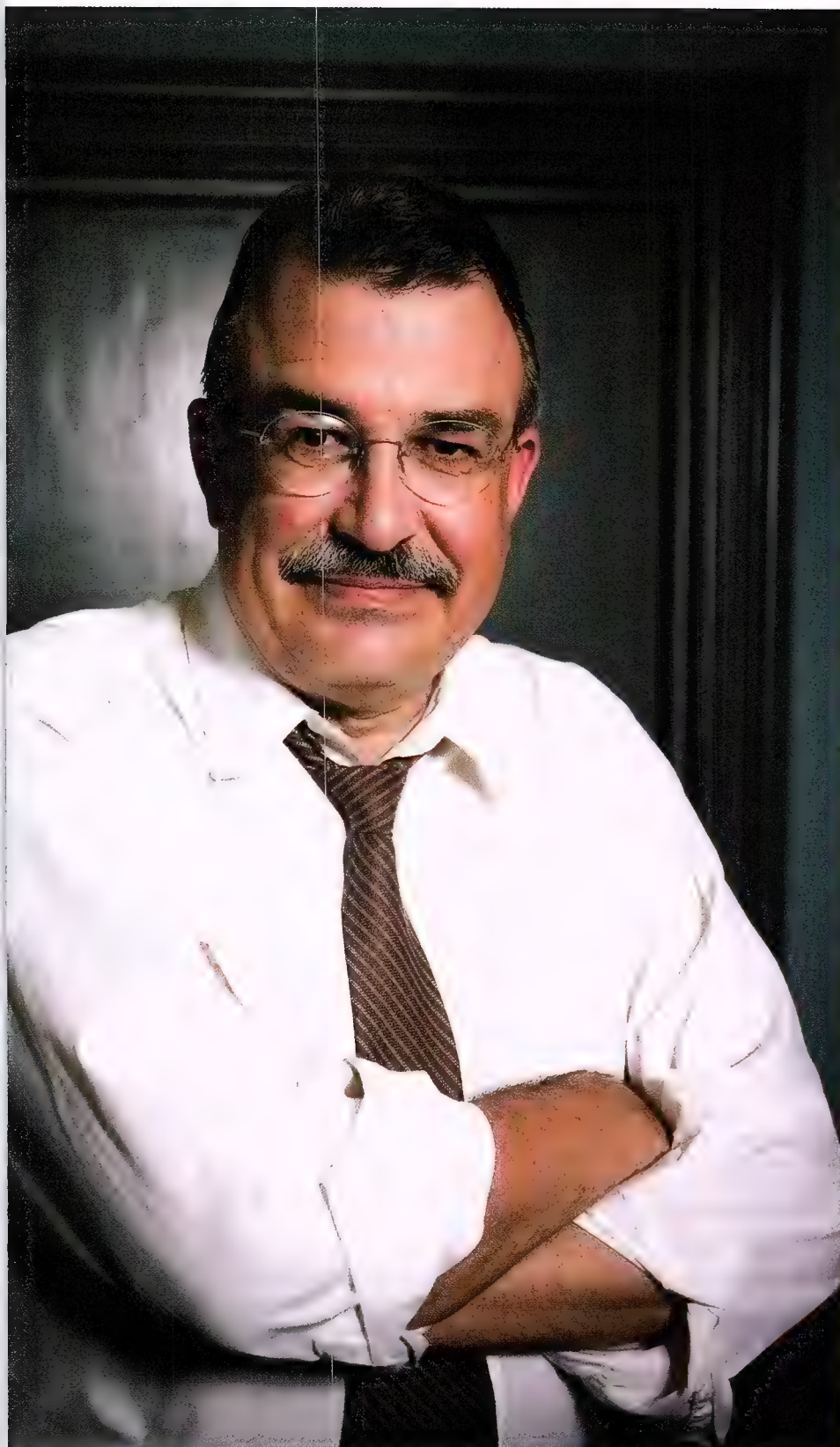
In our view the employee has to decide. They are the best judge. Plus we provide legal help. If someone gets in trouble because of a communication with us we open our treasury.

Do you ever fear for the people you're protecting?

The fear isn't for physical harm, it's the pressure they're under. Marriages are

Profile

Jeff Ruch trained as a lawyer and worked in Californian state government for 17 years, mostly drafting bills for legislative committees. After a stint at the Government Accountability Project, a whistle-blower protection organisation in Washington DC, in 1993 he co-founded Public Employees for Environmental Responsibility, also based in Washington DC, which he now directs.



Ruch aims to deliver whistle-blowing messages without risking the messengers' careers

breaking up, they're doubting their own sanity. We've had someone commit suicide, a woman at the DOI's Bureau of Land Management. She had been reprimanded for correcting something her supervisor put out and given a two-week suspension. In the civil service that's a death warrant. She'd had an impeccable career; she was unmarried, her career was her life. She appealed to her superiors but they refused to remove the suspension. She went home, shot her dogs and killed herself.

Has interference in science got worse under the present Bush administration?

The same thing happened before, but not as much or as pervasively. Now it happens all the time. It's because of this administration's mania with message control. Science doesn't always stay on message; it's messy. Plus in the past, if there was concern about something a scientist did, the director of the agency would take the heat. Now the political influence is felt right down at the field level.

Congress is considering new legislation to protect whistle-blowers. What do you want included?

Scientists need special protection. The traditional whistle-blower definition is very limited: you have to disclose violation of a law, misuse of funds or mismanagement, or a danger to public health or safety. In most cases it's not any of those. So we need something broad saying that federal employees can tell the truth to anyone, barring classified information, without getting in trouble.

Would that be enough to counter government interference in science?

No. There also have to be consequences for people who commit fraud. Even if a whistle-blower wins it is very rare for the perpetrator to suffer any consequence. The flip side would be to promote whistle-blowers. Put them in charge of programmes they were criticising.

Will things change if a Democrat president is elected in 2008?

I'm not sure, because a lot of whistle-blower cases concern development issues, like whether to build on environmentally sensitive land. When it comes to development, Democrats and Republicans are all members of Mr Green's party – the money party. I can imagine a Democrat president who is as obsessed with information control [as Bush is] doing the same kinds of things. We expect to be in business regardless of who is elected. ●

FOREVER BEAR THE CONSEQUENCES

Heinous experiments were performed during the second world war in the name of medical science. A new account of the atrocities argues that to truly grasp present-day medical ethics, these wounds must be remembered, finds **John Cornwell**

“SCIENCE without conscience is the ruin of the soul,” wrote François Rabelais, the French monk, satirist and physician. Yet the notion that science operates above or beyond conscience and morality has persisted in the west for nigh on a hundred years. From Max Weber, the German sociologist of the early 20th century, to Lewis Wolpert, the UK’s erstwhile public-understanding-of-science guru, an influential constituency of thinkers and scientists has maintained that science is value-free. It is the politicians, military and corporations that twist science to good or bad ends, not the scientists: or so the argument goes.

A classic example of the “value-free” contention is the development of the Haber-Bosch process in Germany in the early 1900s, whereby nitrogen was fixed from air for the first time. The process became the basis of cheap fertiliser for food production, while also enabling the near-limitless manufacture of explosives, enabling a blockaded Germany to fight the first world war for four years. Put to both good and bad uses by industry and the military, the Haber-Bosch process and its inventors remained morally neutral: or so the argument goes.

Yet when it comes to bioethics, there is a tendency for governments, in the UK at least, to heed the moral opinions of scientists in preference to ethicists, religious leaders and the general public. A current example is the recent U-turn over human-animal hybrid embryos. In December 2006, UK officials signalled a ban on such experiments, citing “considerable public unease”. Just five months later, in April, following intense lobbying from stem cell researchers, a draft bioethics bill sanctioned such hybrids after all.

“We saw this as an area where these [embryos] could be used for scientific benefit,” says public health minister Caroline Flint – a patently “consequentialist” argument based

on prospective biotech revenues as much as the future good of patients. The US faces similar pleas from stem-cell scientists, yet federal funding for such research, with some exceptions, has been blocked by President George W. Bush, whose evangelical enthusiasms sometimes get the better of him.

Consequentialism derives from the early 19th-century utilitarian philosophy of Jeremy Bentham. It is a thoroughly sensible way of judging actions according to their actual or likely effects for the greatest number.

Utilitarianism is routinely contrasted with moral considerations that belong more to the realms of metaphysics, religion and sophistry than the daylight world of actual repercussions. A consequentialist might condemn drink driving because it causes accidents whereas a puritanical fundamentalist might condemn alcohol in any circumstances because it sullies the soul.

Consequentialism, however, is not without its problems. Could you justify killing one person, for example, to save the lives of five others? And it faces a striking, non-theological counter-argument, originally presented in the 1970s by the late Bernard Williams in the book he wrote with the philosopher J. C. C. Smart entitled *Utilitarianism: For and Against*. While Smart argued for the merits of judging behaviour on its effects, Williams insisted that true moral behaviour for an individual also involves what he called one’s “whole life project”. He cites the example of an unemployed, penniless chemist with a large family. The chemist, who detests chemical weapons, is offered a project at a cutting-edge chemical weapons research centre with the assurance that if he does not accept it, a rival candidate enthusiastic for such weapons will complete the project twice as fast. Consequentialists would say “Take the job!” declared Williams, since there is no scope



Unit 731, in Japanese-occupied China, was home to unspeakable horrors

within their argument for the “whole life project” – principles, scruples and standards, developed through a lifetime of experiences, including family influence and education. From the point of view of his “whole life project”, the chemist might well refuse the job, wrote Williams, despite the prima facie favourable consequences of accepting it.

This is all very well for individuals, but what of the actions of governments? The idea of the “whole life project” writ large, on a national scale, is the underlying theme of a fascinating and timely new book, *Dark Medicine*, based on a conference held at the University of Pennsylvania in 2004, at which the majority of papers were presented by



Japanese and German historians and ethicists, all with a focus on the 20th century.

When ethicists survey the annals of history for instances of inhumanity in the name of science, they tend to cite medical experiments at Auschwitz. Less familiar in the west are the horrors of a Japanese wartime facility known as Unit 731, sited near the city of Harbin in occupied China during the second world war. As many as 10,000 Chinese civilians and Allied POWs died at Unit 731. Vivisection without anaesthesia was practised, and prisoners were deliberately infected with plague, anthrax, gangrene and cholera. Victims were bombarded with a variety of weapons, and subjected to unendurable levels of cold, heat and pressure. About 3000 Japanese medical specialists took part in these atrocities and their rationale, according to

surviving perpetrators, was that the victims were condemned to die anyway and that their deaths could contribute to useful knowledge for the military.

The Japanese and German contributors to this volume argue that an awareness of their separate, but at points comparable, wartime histories has given rise to a systematic caution in the development of their nations' biotechnologies – notably human embryonic stem cell research. The German philosopher Gernot Böhme takes the link between history and current ethical dilemmas even further. On the problem of physician-assisted suicide, for example, he argues that it is impossible to decide the matter simply by weighing the Hippocratic code against consequentialist arguments based on avoidance of "a humanly degraded form of existence". History, he

insists, must also be taken into account. "It is quite impossible to decide on this question today," he writes, "without seeing it against the background of the misuse of the idea of euthanasia – if the practice of the Third Reich can be described as that. What is at issue here, therefore, is not only basic values but our society's historical understanding of itself."

The conclusion of the authors of *Dark Medicine* is that the UK, US and other countries should pay heed to the lessons of German and Japanese history at a time when consequentialist perspectives are increasingly dominated by prospective patient dividends coupled with commercial arguments. Hence, while it is possible to create convincing moral arguments for human embryonic stem cell research on the reasonable basis of benefit to future patients, a major portion of the real consequentialist "case" is the threat of being

"A nation's books on past unethical practice should never be closed"

left behind in race for biotech supremacy.

As the authors put it: "Although this is utterly dubious as an ethical argument to justify any programme in medicine – in today's world, blatant appeals to scientific nationalism get imported into politics. And even into bioethics." Sobered by the knowledge of having gone "too far into the dark side of medical research", Japan and Germany, intensely competitive in most other spheres of technology and industry, are less inclined to seek ethical latitude in bioethics than their Anglo-American counterparts (President Bush's scruples notwithstanding). This is despite any fear of falling behind in the global biotech race.

The take-home message of the 16 contributors to *Dark Medicine* is that a nation's books on past episodes of unethical practice should never be fully closed, and that ethical committees in science and medicine should never neglect the historical perspective of their own and other countries. As one of the book's editors, William LaFleur of the University of Pennsylvania, writes: "A bioethics trained to detect times and ways in which dark motives for doing certain kinds of research are present will be a bioethics more able to tell the scientist and physician which fruit to grasp and which ones to leave unpicked." ●

John Cornwell is director of the Science and Human Dimension Project at the University of Cambridge. He is the author of many books, including *Hitler's Scientists*

Pour in, pop out, move in



It's not hard to put a date on the Futuro house. It looks like a flying saucer and it's made of plastic: it could only come from the 1960s. When the Futuro was launched in 1968, plastics had been around for 60 years: Leo Baekeland invented the first all-synthetic plastic – Bakelite – in 1907, kicking off an industry that transformed 20th-century living. By the 1950s, plastics were popping up all over the home. People wore polyester suits and crimplene frocks, ate from melamine crocks on Formica-topped tables, then stored their leftovers in Tupperware containers. Buckets and bowls were polythene, records were vinyl and the lounge suite was covered in Dralon. It couldn't be long before someone went all the way and made a house entirely from plastic.

MEN loved its wacky space-age lines. Women wanted more cupboards. Failure was inevitable. For a while, though, the Futuro seemed to herald a new way of living in a new type of house. Forget bricks, mortar and wood – this was the age of plastic. No longer something used to fake more expensive woods and marbles, plastic was fantastic just as it was. Designers loved the feel, the colours and the chance to shape things exactly as they liked. Plastic furniture was no longer cheap and tacky, it was chic and pricey. The age of plastic was about to take off, and plastic houses were part of a brighter, better future.

Architects had been toying with the idea of plastic houses well before Finnish architect Matti Suuronen designed the Futuro in 1965. They envisaged a future in which families would live in portable, inexpensive and easy-to-clean homes that they could take with them if they moved. Plastic had so many advantages: it was light and durable; it wouldn't rot and would never be attacked by woodworm or termites. A quick hosing-down every now and again would keep it looking like new.

One of the first attempts to build an all-plastic house in the 1950s failed spectacularly. After a short time in the sun, the epoxy holding its panels together deteriorated and the house fell apart. However, the plastic home gained credibility with the unveiling of the Monsanto House of the Future at Disneyland in California in 1957. Engineers at the Monsanto Chemical Company had asked architects at the Massachusetts Institute of Technology to design them a plastic house. The result was a startling contrast to Snow White's castle: with its four wings atop a pedestal, the House of the Future was the last word in modern design. Made from 15 tonnes of glass-reinforced plastic, it was equipped with every labour-saving gadget its designers assumed we'd all be using by 1987. Once people saw it they were bound to want one.

Visitors to Disneyland did love the house, but they didn't want to live in it. The Monsanto house never went into production, but it did prove remarkably durable. When a demolition crew came to remove it in 1967, the house proved surprisingly resistant. The gang's wrecking ball bounced off it and they had to resort to chewing it to pieces with hacksaws and choker cables.

As the House of the Future was being

consigned to history, Suuronen was ready to reveal his own ideal home. Suuronen wasn't looking to solve a housing crisis or develop a cheap mobile home: he was doing a friend a favour. The friend had asked if he would design a ski cabin that could be easily built on a mountainside and was easy to keep warm.

Suuronen's cabin was an ellipsoid shell made from a sandwich of fibreglass-reinforced polyester plastic, insulated with a filling of polyurethane foam. The unusual shape gave the lightweight shell increased strength, as it does a bird's egg. Continuing his theme, Suuronen added egg-shaped windows and a retractable aeroplane-style door with steps that could be raised and lowered: the result was a house that looked like everyone's idea of a flying saucer.

Polykem, a Finnish company whose usual lines were plastic roof domes and neon signs, won the contract to make the house. Unveiled in March 1968, the cabin was 8 metres across, 4 metres high and had a floor area of 25 square metres. It weighed 2.5 tonnes, came in 16 pieces that could be bolted together on site and was ready to move into in two days. The interior was pure 1960s Scandinavian – open plan, chairs that pulled out into beds, a kitchenette and bathroom, all equipped with plastic fittings.

Later that year, Polykem exhibited some of its products in London, hoping to win orders for its neon signs. Instead, it received hundreds of inquiries about the Futuro. Perhaps the plastic house's time had come? Polykem

“The Futuro came in 16 pieces and was ready to move into in two days”

decided to go into full-scale production and to license companies to manufacture it abroad.

The Futuro house was intended as a holiday home. In the US, however, Philadelphia businessman Leonard Fruchter reckoned the Futuro might appeal to Americans in a way the Monsanto house never had. He set up the Futuro Corporation, with plans to open factories across the US and turn out tens of thousands of Futuros. First, some changes had to be made. The Finnish Futuro was too poky for Americans used to bigger spaces. Lifting the floor 20 centimetres

Plasticity: 100 years of making plastics is at London's Science Museum until January 2009. For information visit www.sciencemuseum.org.uk



increased the floor space by an impressive 60 per cent. Americans also preferred more privacy, so the open-plan living area was sacrificed to provide a lounge-diner and two bedrooms with doors.

The American Futuro was launched the week before the first moon landings, in July 1969. Space travel was the future and the Futuro looked the part. The media loved it. Men loved it. The American housewife wasn't so sure. Maybe it was just a bit too way-out. And there was nowhere to hang those crimplene frocks.

Sales were slow. Only around 60 Futuros were ever manufactured – not all of them as homes. Some became cafes, the Swedish air force used three as lookout towers, and at least two became banks. A second, less bizarre design – the Venturo – did slightly better, but the days of the plastic house were numbered.

Most people blame the failure of plastic homes on the oil crisis of 1973, when people queued for petrol and the price of plastic tripled. But that wasn't the whole story, says Wayne Donaldson, former engineer, architect and now state historic preservation officer for

California. "The oil crisis was a problem but the Futuro house was always expensive for its time." Nor did plastic turn out to be as trouble-free as touted. "The idea that if it's plastic it will last forever and all you have to do is wash it was a misconception," says Donaldson. The plastics of the 1960s and early 1970s were poor compared with today's. Exposed to ultraviolet light, spider cracks soon appeared in the outer coat. "Movement could cause worse cracks, and once water got into them the plastic could sag and deform."

The biggest obstacle of all, however, was people. There was a shift away from traditional housing and people had become much more mobile, says Donaldson. "But that didn't mean they wanted to take their homes with them everywhere they went. People weren't really ready for this type of lifestyle."

Today there are people who are more than happy to live in plastic houses and Donaldson is one of them. His weekend retreat in the San Jacinto mountains is a Futuro he spent years restoring. Like any house, it has its pros and cons, he says. In winter, it heats up in just 15 minutes but in summer it can overheat.

Like a flying saucer perched on a Finnish hill, the Futuro house is a memento of the short-lived age of plastic

The interior walls of glass-reinforced plastic are rather ugly to modern eyes. "Because of the way it's sprayed onto the interior panels the finish is wrinkly and lumpy." Its egg-shape gives the Futuro the strength to withstand mountain winds, though a gale can make the house oscillate, says Donaldson. "That can be kind of nice though and rock you to sleep."

In the 1960s and 70s, people weren't ready to embrace the joy of plastic. So is now a better time? Today, plastics tend to be shunned on environmental grounds. "People in the green community gag at the idea of plastics," says Donaldson. Nevertheless, he believes it's possible to make a sustainable house from plastics. "New plastics are far better and last much longer. Plastic houses are very energy efficient, easy to transport and don't use much energy in their construction. You could fit solar cells on the roof and need not be attached to the energy grid. And making plastic from oil is much better than burning it as petrol." **Stephanie Pain** ●

Mare's milk

How would you like a delicious horse sandwich? The French have their specialist butchers called *boucheries chevalines* and the Italians their *salame di cavallo* sausages, but for some reason horse meat is taboo in the English-speaking world. The same goes for horse milk – yet across much of the world, mare's milk is regarded with no more suspicion than goat's or sheep's. Some societies even consider it a luxury item.

Mare's milk is not a new fad, but it is coming back into fashion. In the early 20th century it was so popular in Germany that it was delivered door to door. More recently it has enjoyed a revival in continental Europe, with equine dairy farms springing up in Belgium, France, the Netherlands and Norway. In central Asia, mare's milk is a staple food, though they prefer it with a kick. In Mongolia, Kazakhstan and Kyrgyzstan the tradition is to ferment it in a horse-hide sack for a few days until it turns into a frothy, acrid and mildly alcoholic beverage called *kumis*, or *airag* in Mongolia.

Where can you go for a refreshing cup of mare's milk? Most of it is sold as a freeze-dried powder, though there are also places where you can get it fresh. The food hall of the famous Le Bon Marché department store in Paris sells bottles of organic *lait de jument*, produced from thoroughbred mares



on an organic farm in Burgundy.

It doesn't come cheap: a quarter of a litre will set you back €12. But according to some connoisseurs, it's worth it. Mare's milk is lighter and sweeter than cow's milk, with notes of watermelon and wild grass, and a nutty undertone.

Novelty aside, there may be good reason to pour some mare's milk on your breakfast cereal. Long thought to have curative properties, mare's milk has been touted as a balm for digestive problems, elixir for the liver and tonic for general malaise. It may be good for the skin too. Legend has it that Cleopatra bathed in ass's milk to soften and whiten her skin; scientists

have recently discovered that ass's milk is indistinguishable from mare's.

Whether there is any truth to these claims remains to be seen, but there is one group of people for whom mare's milk has proven benefits. Infants with severe food allergies will often tolerate mare's milk when all other milk makes them sick. Recent research suggests that this is because mare's milk is closer in composition to human milk than that of any other mammal.

So how on Earth do you milk a horse? It takes considerable skill. Unlike a cow, a mare will not lactate unless her foal is present – and there is the ever-present danger of getting a flying hoof in the face. ●

Know your place

The Telescope

by Geoff Andersen, Princeton University Press,
ISBN 9780691129792
Reviewed by Justin Mullins



MANY technologies change the world, and some even change the way we see the world. The telescope does both, but that isn't

why it is a great invention. This book details the history and technology of a device that is great because it changed our understanding of our place in the universe. Spanning the 400 years since its invention, Geoff Andersen takes us from Galileo to the Hubble telescope and from stargazing to surveillance, with an impressive mix of detail and anecdote. Ending on the search for an Earth-like planet orbiting another star, he leaves us feeling the best is yet to come.

Birth of a new era

Everything Conceivable

by Liza Mundy, Allen Lane/Knopf,
ISBN 9780713998801/
9781400044283
Reviewed by Alison George



ASSISTED reproduction is revolutionising family life in the west: it is now possible to give birth to a child that

is not genetically yours. As a result multiple birth rates have skyrocketed, and this is partly responsible for an increase in US infant mortality rates. In this fascinating and well-researched book Liza Mundy, who writes for *The Washington Post*, brings such hard facts to life through interviews with parents, would-be parents and doctors, as well as dealing with thorny issues like the "selective reduction" of multiple fetuses.

Enigma

Bonus points

No. 1447 Richard England

ALBION, Borough, City, Rangers and United have played another tournament in which each team played each of the others once, two matches being played on each of five successive Saturdays, each team having one Saturday without a match. Points were awarded according to a formula now widely used in rugby: 4 points for a win, 2 points to each team for a draw, and in any match either team or both teams might also gain 1 bonus point.

After the first Saturday's matches Albion

led the tournament, followed in order by Borough, City, Rangers and United, 1 point separating each pair of successive teams. After the second Saturday's matches 1 point still separated each pair of successive teams, but no team was in the same position as after the first Saturday's matches.

If I identified my team and told you what position it was in after the second Saturday's matches you could deduce with certainty which matches had been played on that day and how many points each team had gained in them.

Which matches were played on the second Saturday, and how many points did each team gain in them?

£15 will be awarded to the sender of the first correct answer opened on Wednesday 18 July. The Editor's decision is final. Please send entries to Enigma 1447, New Scientist, Lacon House, 84 Theobald's Road, London WC1X 8NS, or to enigma@newscientist.com (please include your postal address). The winner of Enigma 1441 is A. P. Harrison of Rugby, Warwickshire, UK.

Answer to 1441 The missing link

1	5	7	2
2	1	2	3
8	7	1	4
9	9	5	6

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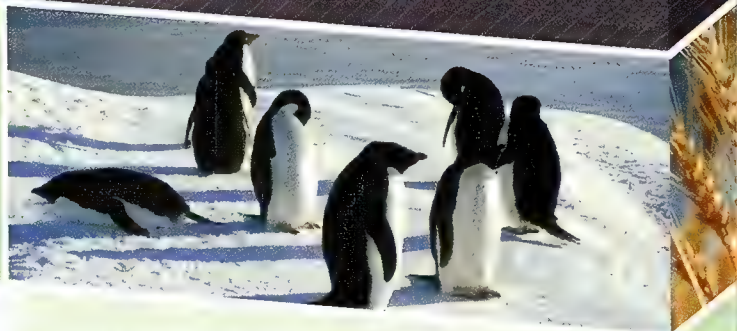
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Dr John Church, CSIRO
Prof. Matt England, University of New South Wales
Mr Ben Fargher, National Farmers' Federation
Dr Eberhard Faust, Munich Reinsurance, Germany
Dr Brian Fisher
Dr Ann Henderson-Sellers, World Climate Research Programme
Mr Kevin Hennessy, CSIRO
Mr Robert Henson, University Corporation for Atmospheric Research, USA

Prof. David Karoly, University of Melbourne
Prof. Amanda Lynch, Monash University
Mr Ian McClelland, Birchip Cropping Group
Prof. Warwick McKibbin, Australian National University
Dr Jerry Meehl, National Center for Atmospheric Research, USA
Prof. Neville Nicholls, Monash University
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- national and international case studies
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CSIRO and the Bureau of Meteorology will also be releasing new climate change projections for Australia at the conference.

KEY DATES

- 15 JUNE Deadline for submission of abstracts
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- 31 JULY Early-bird registrations close
- 1 AUGUST Final date for registration by presenters

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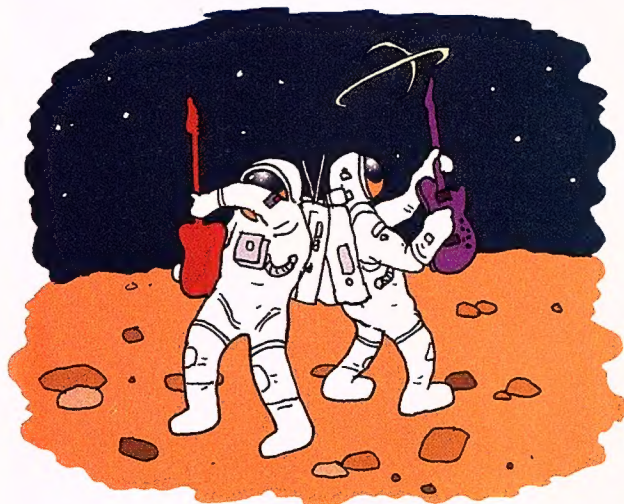
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Feedback



WOULD you like to know what Deep Purple sound like playing on Saturn's moon Titan?

No, the band hasn't actually been there, and nor has a recording of its work been dropped onto Titan to be broadcast back to Earth. However, physicist Andi Petculescu at the University of Louisiana, Lafayette, and mechanical engineer Richard Lueptow of Northwestern University in Evanston, Illinois, have developed a model that predicts the acoustic properties of gas mixtures. They then played the opening bars of Deep Purple's classic track *Smoke on the Water* through filters that mimic the different atmospheric conditions on Earth, Mars, Venus and Titan.

The track sounds best on Titan, which has a nitrogen-methane atmosphere that is thicker than Earth's, making the music magnificently loud, with a rich, thumping bass.

You can hear it for yourself at <http://tinyurl.com/yt4ae8>, and find out more on *New Scientist's* space blog at <http://tinyurl.com/zywkgr>.

THE can of Car Pride Wheel Clean that Dave Taylor bought told him: "Effectively removes dirt and grime from any wheels. Works on steel and alloy wheels, and metal and plastic wheel trims. Directions: Shake can thoroughly and spray directly on to surface. Allow to soak for 30 seconds but do not allow to dry. Wash off with plenty of water from a hose pipe, standing well back to avoid splashing on to clothes. Very dirty wheels may need a second application. Avoid contact with glass,

plastic and paintwork... Do not allow to enter watercourses."

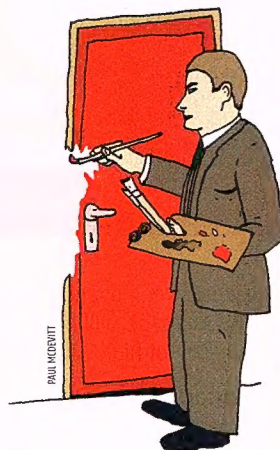
Taylor wants to know: "Are you supposed to use it on plastic or not?" And: "What are you supposed to do with all the water from the hosepipe if you mustn't allow it to enter watercourses? Catch it all and bury it in a field?"

QUANTUM mechanics may apply in Scotland to buses that merge in Lanarkshire (Feedback, 9 December 2006). Errol Kellas writes from Australia to point out that things were no simpler in earlier, pastoral times – or at least not in mythical ones created for marketing purposes. Indeed, at <http://tinyurl.com/yr2ace> Long-Walking Lonesome Bob Badger informs us what he could not have done without his Foot Balm: "Two paths diverged in the woods and I... I took both of them."

Similarly, many readers have told us of their difficulty in obeying signs in trains that urge: "Use all doors to exit". And when Emmet McMahon was travelling into London, he was struck by a notice on one of the stations that said "Let other people off the train first". He reflected that it is a very good thing that not everybody in London can read English, otherwise nobody would ever get off the trains.

STRUGGLING in a similar state of quantum uncertainty, Owen Courtis tells us of a sign on a door at a shopping centre in his locality which reads "This door is to remain closed at all times".

"As one can only pass through an open door," he muses, "the effect of the sign is to render the thing just another part of the



Another splendid website note found by Andrea Gill: "The Botanical Society of America web site is transmitted using recycled electrons – GO GREEN"

wall. Had René Magritte been employed by the centre, they could have achieved the same effect by having him merely paint an image of a door on the wall, decorated with the legend 'Ceci n'est pas une porte'."

APPLYING online for life insurance from the UK's Nationwide building society, Beth Pipe was given the option of a joint or sole policy and opted for sole. When the quote came back it was accompanied by the statement "Payable on first death within the term of the plan".

Pipe is impressed that Nationwide have such faith in medical science that she's allowed to die more than once – but disappointed not to be told how much she'd get on subsequent deaths.

DON'T all rush now. Here's a promo from Amazon: "As someone who has expressed interest in books by Jane Goodall, you might like to know that Jane Goodall's *Return to Gombe: Reflections on a life's work in Africa* will be released on December 31, 2035. You can pre-order your copy at a savings of \$8.48 by following the link below..."

But how much will \$8.48 be worth then? Could be a real bargain.

FINALLY, Paul Jordon found the following sentence on a University of Cambridge web page: <http://tinyurl.com/yc3rs>. "It could be argued that various misunderstandings of how convection operates in stars lead to the greatest differences in their long-term evolution."

Jordon notes: "It seems Cambridge astrophysicists are so clever that they can influence the evolution of stars by their degree of understanding of convection."

You can send stories to Feedback by email at feedback@newscientist.com. Please include your home address. This week's and past Feedbacks can be seen on our website.

The last word

Last Words past and present, plus a full list of unanswered questions, are available at www.newscientist.com

KABOOM SQUARED

I've just got back from a fireworks display where some of the fireworks exploded into a square shape. How do they do that?

The firework was probably an aerial shell fired from a mortar tube. Such shells are usually spherical and contain stars, or pellets of coloured pyrotechnic material, arranged around an explosive charge. This charge both ignites and propels the stars in all directions at the apogee of the shell's flight.

The stars are arranged in a square when the shell is being constructed, positioning them at slightly different distances from the centre. The propulsive force on each star will be the vector sum of all the explosive forces surrounding it; because each star is in a slightly different position, the force on each is also slightly different. Those placed nearer the centre of the shell will experience less outward force than those further from the centre – the furthest being the stars that form the corners of the square. If the stars are uniformly arranged against the shell wall they will form a spherical burst. Shapes such as hearts and smileys are made by arranging stars asymmetrically.

One potential problem is that shells tend to spin on their trajectory, so there is a possibility that spectators will see this kind of firework burst end-on. If this were to happen, the stars would appear as a line rather than a two-dimensional shape.

*Tony Charity
Lowestoft, Suffolk, UK*

Questions and answers should be kept as concise as possible. We reserve the right to edit items for clarity and style. Please include a daytime telephone number and email address if you have one. Questions should be restricted to scientific enquiries about everyday phenomena. The writers of all published answers will receive a cheque for £25 (or the US\$ equivalent). Reed Business Information Ltd reserves all rights to reuse question and answer material submitted by

Memorable answer? The Last Word and New Scientist have teamed up with Crucial Technology (www.crucial.com/uk) and will be awarding each successful author a 512MB Gizmo! overdrive.

BEE PLUMP

Can insects get fat? (Continued)

With my colleague James Marden I have described (among other symptoms) infection-associated obesity in a dragonfly species. Infected dragonflies show an inability to metabolise fatty acids in their flight muscles and so build up lipids in their thorax, leading to a 26 per cent increase in thoracic fat content. The suite of symptoms caused by this infection includes decreased flight performance and reproductive success in male dragonflies (*Proceedings of the National Academy of Sciences*, vol 103, p 18805).

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CRUEL WORLD

Scientists have worked out the evolutionary basis for many behaviours such as altruism and jealousy. However, over the millennia, people have been unbelievably and gratuitously cruel to each other. The evolutionary advantage of this is not obvious. So what is the biological basis of human cruelty? (Continued)

One of your previous correspondents seeks to exclude women from the discussion of the survival of unbelievable and gratuitous cruelty as a human trait. They have not been so dominant in the history of large and

readers in any medium or format.

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dramatic behaviours, perhaps because they have seldom been in a position to initiate them. When they are in such a situation we see such exceptions as the 16th-century Hungarian serial killer Elizabeth Báthory, and ancient Roman females of the family that produced her role models, Caligula and Nero.

Today, in the everyday world, wannabe alpha females can create just as much nastiness as males, if not more. As a primary schoolteacher I have to deal with bullying. In 40 years, boy bullies, as opposed to boys who sometimes bully, have been rare. Female bullying is much more common, much more difficult to deal with, and delivers much more long-lasting, though less visible damage. "You can be my friend if you promise never to speak to her ever again," is the style of approach girls use.

I did ask the hangers-on once why they wanted to be the friend of someone who had demanded they dump another friend. They had no answer, even expressing disbelief that I should ask, despite being upset by

the situation. Girls bullied by other girls are excluded, made to feel of no value, and have been driven to suicide. Females cannot be excused complicity in the production of cruelty.

I don't know why the trait of cruelty survives, but I do know why the trait of compliance survives. Survival depends on not being cast out from the central group. And while that trait persists, so do the queen bees.

*Penelope Stanford
Greenhithe, Kent, UK*

THIS WEEK'S QUESTION

Lunatic cacti

My *Cereus forbesii* cactus flowered last night, coinciding with a full moon (see Photo). The *Selenicereus grandiflora* cacti that I had in Bangladesh always flowered at or within a couple of days of a full moon or, more occasionally, a new moon. How is flowering in such plants triggered by the lunar cycle?

*Hugh Brammer
By email, no address supplied*



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